2013 Wyckoff Upland NAPL Field Investigation Technical Memorandum

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This technical memorandum documents and presents initial results from the Wyckoff Upland Non-Aqueous Phase Liquid (NAPL) Field Investigation (the Upland Investigation) conducted by CH2M HILL for the U.S. Environmental Protection Agency (EPA) as part of the Wyckoff/Eagle Harbor Superfund Site Operable Unit-2/Operable Unit-4 Focused Feasibility Study (FFS). This technical memorandum presents site data collected using Dakota Technologies' Tar-specific Green Optical Scanning Tool (TarGOST). TarGOST is a Laser-Induced Fluorescence (LIF) field tool used to semi-quantitatively determine the relative distribution of NAPL in the subsurface. The TarGOST data generated from this field investigation will be used to support preparation of the FFS including remedial target area identification, technology screening, and alternatives analysis.

CH2M HILL conducted the site TarGOST investigation activities during two separate phases in January through March 2013 in accordance with procedures outlined in the *Wyckoff Upland NAPL Investigation Quality Assurance Project Plan* (QAPP) (CH2M HILL, 2013a). Specific objectives of this field investigation relevant to TarGOST data collection included:

- Evaluate the horizontal and vertical extent of NAPL within the Project Area;
- Assess NAPL occurrence in relation to hydrostratigraphy; and
- Evaluate the mobility of NAPL at the site and the potential for NAPL to migrate through the aquitard and/or sheet pile wall.

This initial evaluation of the TarGOST data set focuses on the first objective, evaluating the horizontal and vertical extent of NAPL within the Project Area. In addition, the EPA, Sundance Environmental and Energy Specialists, Ltd. (Sundance), and CH2M HILL are working in conjunction to model the TarGOST dataset in 3 dimensions using geostatistical interpolation methods. A draft report of the results from this evaluation will be completed in fall 2013.

This technical memorandum is divided into the following sections:

- **Section 1 – Background** describes the Upland NAPL Investigation Project Area and provides an overview of the field investigation components.
- **Section 2 – Deviations from the QAPP** documents minor variations from planned procedures.
- **Section 3 – Quality Assurance and Quality Control** describes methods, procedures, documentation, and quality checks for the field investigation and data interpretation.
- **Section 4 – Investigation Results Summary** reports findings and observations from the project work.
- **Section 5 – Conclusions** summarizes conclusions and discusses remedy selection implications.

- **Section 6 – References** presents works cited in this document.

The following tables, figures, and supporting appendices referenced in the text are provided at the end of the technical memorandum.

Tables

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Appendices

1 Background

This section presents an overview of the Project Area as well as a detailed description of the components of the field investigation conducted.

1.1 Project Area Description

The Wyckoff/Eagle Harbor Superfund Site encompasses the contaminated areas of Eagle Harbor and adjoining uplands of the former Wyckoff wood-treating facility. The Superfund Site is divided into four operable units (OUs):

- East Harbor OU (OU-1) – subtidal and intertidal sediments in Eagle Harbor adjacent to Wyckoff Point.
- Soil OU (OU-2) – surface and unsaturated subsurface soil in the former Wyckoff wood treating process and storage area.
- West Harbor OU (OU-3) – sediments and uplands of former shipyard.
- Groundwater OU (OU-4) – groundwater and soil in the saturated zone beneath the soil OU.

The Soil and Groundwater OUs consist of the approximately 19-acre upland area affected by releases of wood treating chemicals during the 85-year operating history of the Wyckoff facility. The Project Area that was the focus of the upland NAPL field investigation is an approximately 8-acre portion of the Soil and Groundwater OUs where wood treatment operations were centered and where large volumes of subsurface NAPL have been observed in wells and borings. Further descriptions of the site setting, historical activities, and other background information are provided in the Data Quality Objectives appendix of the QAPP (CH2M HILL, 2013a).

1.2 Field Investigation Overview

The upland investigation included the following field activities:

- **TarGOST LIF Probing (Phase 1 – January 14 through February 8, 2013).** An initial round of LIF field screening using the TarGOST probing tool to qualitatively assess presence or absence of potential NAPL, as guided by historical NAPL occurrences.
- **TarGOST LIF Probing (Phase 2 – February 25 through March 22, 2013).** A second round of TarGOST investigation to extend the Phase 1 grid and evaluate spatial data gaps, based on results of Phase 1.
- **Confirmation Soil Coring (Phase 1 and Phase 2).** Soil cores were collected through either sonic or direct push drilling methods and visually logged, and then selected intervals were analyzed ex-situ using the TarGOST probing tool to verify LIF probing results and correlate to visual NAPL observations.

TarGOST replicate probes were completed at selected locations to evaluate LIF signal response variability. Table 1-1 presents a summary of the explorations completed in comparison to QAPP target objectives.

1.2.1 TarGOST Phase 1 and Phase 2 LIF Probes

The QAPP (CH2M HILL, 2013a) specified 50 initial target boring locations for Phase 1 at the Upland Investigation site. Phase 1 TarGOST probes were advanced at 77 locations at the site (Figure 1-1 and Table 1-2) because sufficient progress was made on the initial target borings, as specified in the QAPP, so additional boring locations were added. TarGOST field data is presented in Appendix A, including raw field logs (Appendix A-1) and daily calibration records (Appendix A-3). Field notes are included in Appendix B. Seven field replicates were also completed for a total of 84 Phase 1 TarGOST probes. As anticipated by the QAPP, the Phase 1 locations were adaptively shifted in the field to optimize data gathering activities for general areal coverage outward from and between known historical NAPL occurrences. Phase 1 TarGOST locations were further adjusted in the field based on real-time TarGOST results and site conditions at the time of work. As examples of site conditions encountered, boring locations were adjusted in the field based on the presence of existing foundations, shallow refusal depth, and access issues related to topography and site drainage. In accordance with QAPP objectives, the Phase 1 TarGOST probes were advanced to refusal, expected to be the glacial till layer, at the majority of the exploration locations. Exceptions included 2013T-010, 2013T-013, 2013T-050, and 2013T-051, where the probe was approaching the expected bottom depth of the aquitard. Probing was discontinued to prevent probing through the bottom of the aquitard and creating a preferential flow path through the aquitard.

Phase 2 TarGOST probes were completed following the Phase 1 field effort (Figure 1-1 and Table 1-2). The objective of the Phase 2 TarGOST probes was to achieve additional coverage and delineation of NAPL in soil between and beyond the Phase 1 locations. The locations for the Phase 2 TarGOST probes were selected utilizing Phase 1 results to provide step-out or fill-in coverage. A total of 64 Phase 2 locations were completed. Twelve borings were conducted outside of the sheet pile wall and the Former Process Area. These borings were performed on the West Beach along the exterior of the sheet pile wall and stepped out from the wall to investigate potential continuity with elevated TarGOST responses on the interior side of the wall. These borings are identified on Figure 1-1. As for Phase 1, the nominal target depth of the Phase 2 TarGOST borings was refusal, expected to be the glacial till. All Phase 2 cores were advanced to refusal.

1.2.2 Confirmation Soil Cores

Confirmation soil cores were advanced at 10 selected TarGOST Phase 1 locations and 10 Phase 2 locations (Figure 1-1 and Table 1-3). Soil and NAPL descriptions are presented on the Direct Push and/or Rotosonic Soil Core Logs presented in Appendix C. All cores were logged in accordance with procedures described in the QAPP Field Procedures appendix as follows.

1.2.2.1 Visual NAPL Observations

Soil cores were visually examined for the presence of NAPL. The following descriptions of NAPL were used to document the extent of NAPL observations:

- *No visible evidence of NAPL* – No visible evidence of oil on soil sample
- *Sheen* – Sheen as described by the sheen testing methodology described below
- *Oil Stained* – Visible brown or black staining on soil. Can be visible as mottling or in bands. Typically associated with fine-grained soils.
- *Oil Coated* – Visible brown or black oil coating soil grains. Typically associated with coarse-grained soils.
- *Oil Wetted* – Visible brown or black oil wetting the soil sample. Oil appeared as a liquid and was not held by soil grains.

Sheen screening is a method that can be effective in detecting petroleum-based products in concentrations lower than regulatory cleanup guidelines. Water sheen testing involved the placement of soil in water, then observation of the water surface for signs of sheen. Sheens were classified according to the following descriptions provided in the QAPP (CH2M HILL, 2013a):

- *No Sheen* – No visible sheen on water surface
- *Slight Sheen* – Light colorless film; spotty to globular; spread is irregular, not rapid; areas of no sheen remain; film dissipates rapidly
- *Moderate Sheen* – Light to heavy film, may have some color or iridescence, globular to stringy, spread is irregular to flowing; few remaining areas of no sheen on water surface
- *Heavy Sheen* – Heavy colorful film with iridescence; stringy, spread is rapid; sheen flows off the sample; most of water surface may be covered with sheen

1.2.2.2 Soil Lithologies and Geologic Units

Soil cores for the Upland Investigation were logged in the field in accordance with the QAPP Field Procedures. Field logging included identification of soil types using the American Society of Testing and Materials (ASTM) D2488-09a method, Standard Practice for Description and Identification of Soils (Visual-Manual Procedure). Lithologies were further divided into geologic units consistent with criteria developed by CH2M HILL during the *Final Remedial Investigation (RI) Report for the Wyckoff Soil and Groundwater Operable Units* (CH2M HILL, 1997), and by the U.S. Army Corps of Engineers (USACE) for the *Off-Shore Field Investigation Report for the Barrier Wall Design Project* (USACE, 1998). These geologic units were subsequently described with minor modifications in the USACE's *Comprehensive Report, Wyckoff NAPL Field Exploration, Soil and Groundwater Operable Units* (2000) and in CH2M HILL's *Soil Boring and Monitoring Well Construction Summary* (CH2M HILL, 2009).

Geologic units and descriptions applicable to the Upland Project Area are as follows:

- **Fill:** Brown, fine sand containing wood debris, anthropogenic debris, and infrequent shell fragments. Fill materials may be associated with historical shoreline development and modification activities.
- **Surficial Marine Sediment:** Dark olive, harbor bottom silt and clay, commonly with abundant wood chips and wood and plant debris.
- **Marine Silt:** Olive-gray silty sand with thin layers of gravel, to silt or clay, and containing abundant shell fragments.
- **Marine Sand and Gravel:** Gray to dark gray, loose to dense sand and gravel with local cobbles, and low silt content and common shell fragments.
- **Marine Sand and Gravel (Gravel Zones):** Marine Sand and Gravel zones with dominant gravel and local cobbles, transitional into less coarse sediments.
- **Marine Sand:** Dark greenish gray to medium dark, dense to very dense sand with little silt or gravel.

Zones of dominantly Wood Pulp and Wood Debris were also added as geologic units in the Project Area in the *2012 Field Investigation Technical Memorandum – Wyckoff OU-1 Focused Feasibility Study* (CH2M HILL, 2013b). These zones are characterized by dark gray/brown to black decomposing fibrous or pulpy wood.

Direct push and rotosonic sediment coring logs from the current Upland Investigation are provided in Appendix C-1 of this technical memorandum. CH2M HILL reviewed the lithologic information from the historical exploration logs to assign the geologic unit designations to the current investigation boring logs.

1.3 Borehole Abandonment

Each TarGOST boring, soil boring, and sample core collection location was abandoned by filling from the total depth of the hole to the ground surface with Class G cement with 30% silica flour mixed as described in the QAPP Field Procedures (CH2M HILL, 2013a). The only exceptions were the TarGOST and confirmation borings advanced on the West Beach. These were using a bentonite slurry.

1.4 Decontamination and Investigation-Derived Waste

Reusable NAPL investigation equipment including hand tools, TarGOST probe tips, and push probe drilling equipment was decontaminated in accordance with methods described in the QAPP Field Procedures.

- Disposable equipment and accessories including personal protective equipment (PPE), soil core liners, and soiled paper towels were managed as investigation-derived waste (IDW) for off-site disposal. IDW was placed in labeled drums on the east decontamination pad on the Wyckoff uplands. The drummed IDW is currently awaiting disposal as RCRA-listed Hazardous Waste.
- The rods, tires, and undercarriage of the direct push drill rig were decontaminated at the Wyckoff upland east decontamination pad prior to each exit of the vehicle from the exclusion zone. Wash pad decontamination

utilized a steam cleaner capable of 2,000 pound per square inch pressure and a temperature of greater than 212 degrees Fahrenheit. Decontamination fluids were disposed of through the on-site treatment system.

- Relatively small quantities NAPL-contaminated soil generated during the subsurface investigation were deposited in the Wyckoff uplands within the exclusion zone. These disposal locations are beyond the limits of site roads, walking paths, or other access corridors.

2 Deviations from the QAPP

This section describes changes enacted in the field to the borehole nomenclature and the decision to postpone NAPL mobility analysis as described in the QAPP (CH2M HILL, 2013a).

2.1 Borehole Nomenclature

Borehole nomenclature was changed slightly in the field to better represent the activities being performed. In the QAPP, field replicate probes were to be designated as -00Xa to denote association with primary TarGOST location -00X. The nomenclature was changed in the field to -00XR to denote that the probe was a Replicate of location -00X. Visual confirmation borings were to be designated as 2013-DP-00X to indicate direct push. However, only a portion of the visual confirmation borings were conducted with a direct push rig and the rest were completed with a sonic drill rig. Also, since collection of mobility cores, planned to be designated 2013SC-00X, was delayed to a later portion of the project, the visual confirmation boreholes were designated 2013SC-00X to designate that they were a soil core, rather than a TarGOST probe borehole.

2.2 Replicate TarGOST Probes and Soil Core Frequency

The QAPP specifies that field confirmation replicate TarGOST probes and soil cores from direct-push or sonic drilling equipment were to be completed at approximately 10 percent of the TarGOST probe locations. Seven replicate locations and ten soil cores were advanced during Phase I TarGOST activities. As soil cores were deemed more valuable than replicates, for the Phase II TarGOST activities ten soil cores but no replicate locations were advanced. Consequently soil cores were collected at a 14 percent frequency, while replicates were collected at a 5 percent frequency relative to the 10 percent frequency target.

3 Quality Assurance and Quality Control

Procedural methods, documentation, and quality checks for field investigation and data interpretation tasks were conducted as described in the QAPP and QAPP Field Procedures. Quality assurance and quality control (QA/QC) measures were implemented in accordance with these documents. This section provides additional description of TarGOST calibration procedures and data usability.

3.1 TarGOST Equipment Calibration

The calibration procedure for the TarGOST equipment involved both qualitative and quantitative field calibration of the reference emitter (RE), measurement of potential background interference, and real-time field review of the waveform output. These procedures are described in more detail in the following subsections.

3.1.1 Standard LIF Reference Emitter (RE) Field Calibration Procedure

The following description represents Dakota Technologies’ standard operating procedure for RE field calibration. Dakota Technologies performed RE calibration as a standard field quality assurance procedure prior to each TarGOST probe. Prior to conducting each TarGOST probe, two calibration measurements are recorded: one for RE and one for background. RE calibration is performed to verify that TarGOST signal response is within a suitable range relative to standard RE material placed on the TarGOST detector window for LIF transmission. The RE is a calibration for the response of the LIF system to the standard fluorescence signature, not a method of converting fluorescence to a known concentration. The RE material used is a standard synthetic substance with consistent fluorescence properties. Dakota performs calibration for two main purposes:

- **Qualitative examination of the performance of the TarGOST instrumentation.** The Dakota operator reviews the RE response waveform to verify that it conforms to the expected waveform shape. This confirms that the TarGOST signal channels (filters, etc.) are intact and functioning. A distorted RE waveform indicates potential damage of the detection system optics.
- **Quantitative calibration of the TarGOST instrumentation.** The operator sets the proper signal intensity for the RE standard by adjusting laser energy as needed to maintain the signal within an optimal light detection range. TarGOST signal measurements during probing are normalized to a percentage of the standard RE fluorescing and scattering substance. For example, a 100% RE reading means that a measured material has a fluorescence/scatter signal identical to that of the RE. A 200% RE means a substance has a fluorescence/scatter signal twice that of RE.

The typical range of TarGOST RE response falls between 1,000 and 2,000 picovolt-seconds (pVs). These units represent a measure of waveform area. Precise RE intensity “tuning” to a certain value is not needed because all signals are reported as a percentage of the reference emitter signal output (%RE). Daily RE field calibration records are presented in Appendix A-3.

3.1.2 Background Measurement

The background measure assesses the optical quality of the instrumentation setup. Sources of signal in the background include fiber and filter auto-fluorescence, mirror and window fluorescence, and scatter from worn windows. The background waveform has no mathematical impact on the data collected (i.e., it is not subtracted) and is measured only as a data quality parameter to verify that there are no significant defects on the optics mirror, window, fiber, and related components.

Background values can vary widely. In terms of area, the values can range from 0 to 50 pVs. As the background increases beyond the 50 pVs threshold for TarGOST, equipment wear may be indicated, with a new window and a reassembly of the probe potentially needed. However, the 50 pVs threshold is a general quality guidance criterion based on judgment of Dakota, and there is no hard cut-off value. Only a few exceedances of the 50 pVs background guideline were noted during this investigation (Appendix A-3), but these exceedances were not deemed by Dakota to represent significant defects in the instrument setup optical quality.

3.1.3 Waveform Review

Dakota reviewed the raw TarGOST logs in the field for obvious aberrations or indicators of spurious signal response, unexpected conditions, equipment malfunction, potential interferences, or other problems. Limited interference from selected types of shell fragments and other organic material such as wood debris were observed. Except for potential organic interference, no other field QA issues were noted (Randy St. Germain/Dakota Technologies, personal communication, February through April 2013). No additional interpretive refinement of the raw TarGOST logs to address organic interference issues and evaluate the NAPL types present was determined to be necessary for the Upland TarGOST dataset (Randy St. Germain/Dakota Technologies, email communication, 2013). The raw TarGOST field logs are presented in Appendix A-1.

3.2 Replicate TarGOST Probes

Replicate TarGOST probes were completed at selected locations to evaluate the near-field consistency and variability of TarGOST signal response. A total of 7 replicates were completed at 9 percent of the Phase I TarGOST probe locations (Table 1-1). Phase 1 TarGOST replicates included locations 2013T-001/001R, 002/002R, 027/027R, 036/036R, 037/037R, 056/056R, and 068/068R. Though replicate probes were generally performed on the same day as the original probes, some replicates (2013T-002/002R, 036/036R, 037/037R, and 068/068R) were completed on days following the original probes due to field scheduling.

“Butterfly” figures depicting mirror images of the primary probe logs and adjacent or nearby replicate are presented in Appendix A-2.TarGOST logs from the replicates were visually compared to logs from the primary probes to assess TarGOST signal consistency and variability. Three primary metrics of reproducibility were evaluated on the TarGOST logs: presence, magnitude, and offset.

- **Presence –** Review of the butterfly plots in Appendix A-2 shows consistent correlation between the presence of NAPL in the parent and replicate probes. While evaluating the presence or absence of NAPL is subjective, as described in the next section, the plots show consistently elevated TarGOST response levels indicating the presence of NAPL.
- **Magnitude –** There is variability evident between the plots in regards to the magnitude of %RE responses. While the depths of elevated NAPL and the presence are relatively comparable, the spikes may vary by 100%RE or more. For example, the elevated NAPL response in boring 002/002R at a depth of approximately 16 feet below ground surface (ft bgs) is 110%RE in 002 and 275%RE in 002R.
- **Offset –** Another factor to consider in the reproducibility between the parent and replicate probes is the offset between NAPL responses. In most of the borings some apparent vertical offset is observed in the NAPL responses. For example, in 027 and 027R, the elevated NAPL response at 38 to 39.5 ft bgs in 027 likely corresponds to the NAPL response observed at 34 to 36 ft bgs in 027R. This offset could have been due to the presence of cobbles, etc. that the probe had to maneuver around, or slight deviations from vertical during probe advancement.

Review of the TarGOST replicate probe results indicates that the TarGOST signal response is reliably reproducible, but subject to inherent variability based on irregular distribution of NAPL, even on a relatively local scale.

3.3 Confirmation Soil Cores

Direct push or rotosonic soil cores were advanced at selected TarGOST probe locations to evaluate visual NAPL presence/absence in relation to TarGOST signal response. Soil core locations captured TarGOST signal responses over a range of suspected range of NAPL impact conditions. A total of 20 soil cores were completed at 14 percent of the TarGOST probe locations (Table 1-1). This frequency exceeded the minimum 10 percent frequency required by the QAPP. Phase 1 soil cores included locations 2013-SC-001, -002, -006, -036, -041, -045, -046, -055, -068, and -072. Phase 2 soil cores included locations 2013-SC-013, -014, -054, -070, -101, -106, -119, -127, -152, and -155. Soil coring logs are presented in Appendix C-1.

Ex-situ confirmation TarGOST results and visual NAPL observations from the soil cores were combined in one graphic to compare TarGOST probing and replicate probe results. These summaries are presented in Appendix C-3. Table 3-1 summarizes comparative results of NAPL presence indicated by TarGOST signal response, TarGOST replicates, and soil core visual observations. Visual NAPL in soil cores exhibited variable “correlation” with TarGOST log signals, as summarized below for selected locations:

- Locations 013, 046, and 068 are examples of locations with reasonably good association of TarGOST and soil core NAPL occurrence data.
- Other locations exhibited relatively good correlation of visible NAPL with TarGOST signal response at one or some depth intervals, but not at other depth intervals. Examples include locations 002/002R, 054, and 072.

The above examples demonstrate that soil coring observations are generally consistent with TarGOST probing results, but tend to exhibit some variability. This is not unexpected, given the inherent variability of subsurface stratigraphic conditions and inferred NAPL distribution.

Additional factors also affect comparison of NAPL observations in the soil cores with TarGOST results:

- Heaving sand may inhibit soil recovery in direct push cores, potentially leading to under-representation of NAPL occurrence in these zones.
- Coring can compress the soil within a sampling interval and may smear or mobilize NAPL away from the point of origin, potentially leading to redistribution or loss of NAPL.

- NAPL observations are subjective and based on the descriptive criteria identified in the QAPP. NAPL coatings, wetted areas, globules, and other accumulations can quickly dissipate into more diffuse sheens, and not be observed as actual NAPL occurrences.
- Drill tooling can encounter buried debris or cobbles which may result in angled offset of direct push tooling as the boring is advanced. This may result in significant offset between the TarGOST probe and the soil core at greater depths.

NAPL observations from the soil cores should be interpreted with a view to these constraints, but are otherwise suitable as one line of evidence for supporting the validity of TarGOST investigation results. Additional description of the soil types encountered during coring is presented in Section 4.

4 Investigation Results Summary

Upland investigation data were compiled from field logging records presented in the appendices of this technical memorandum. Following QA review, the investigation data were evaluated to determine the %RE indicating presence or absence of NAPL, inferred NAPL extent and distribution, and preliminary association of NAPL with soil type.

4.1 Comparison of TarGOST to Confirmation Boring NAPL Observations

In raw form, the TarGOST data do not explicitly indicate presence or absence of NAPL. Interpretation is needed to select a %RE value that represents a transition or cutoff between the presence or absence of NAPL. To accomplish this, three data types were analyzed to evaluate the cutoff between the presence or absence of NAPL: the raw in-situ TarGOST data logs, the visual NAPL observations recorded for the co-located confirmation borings, and the ex-situ TarGOST readings performed on selected intervals of the confirmation boring cores. Overall, 20 confirmation cores were completed in Phases 1 and 2 of sampling, totaling 1,039 total feet of confirmation cores. Of these, 58 percent recovery was achieved for the entire dataset, totaling 603 ft of comparable data with in-situ subsurface TarGOST readings. 281 ex-situ soil samples were analyzed for TarGOST readings as well as logged for soil type and NAPL observations. Each soil sample has multiple individual TarGOST readings for a total of 5,660 individual readings.

It is important to note that the evaluation of each data type has its limitations. For instance, the evaluation of raw in-situ TarGOST data logs primarily relies on professional judgment, comparisons between the in-situ TarGOST readings and the co-located confirmation boring visual observations were limited to intervals of core recovery, and ex-situ TarGOST readings are likely biased towards the presence of NAPL since more samples were taken where positive visual NAPL observations were made. These inherent limitations were considered in the analysis of the data sets. In general, visual observations were considered to be the most reliable of the data sets despite some inherent limitations in this assumption. To accommodate for some of these limitations, less emphasis was placed on the specific NAPL observations than on the general presence or absence indicated by visual observations due to variability in logger interpretation. In addition, the methods used to compare TarGOST readings with visual observations were intended to take into account the potential offset between readings and observations which may occur due to natural variation in NAPL distribution on a local scale and the possible challenges of soil coring as listed in Section 3.3.Three different approaches were explored to determine the TarGOST response signal cutoff appropriate to delineate the presence versus absence of NAPL:

1. **Visual comparison of in-situ TarGOST response to visual NAPL observations from confirmation soil cores.** As noted above, this method relies on professional judgment to select the %RE differentiating presence versus absence of NAPL through a comparative review of TarGOST logs versus soil core NAPL observations.
2. **General statistical comparison of all in-situ TarGOST response intervals with corresponding visual NAPL observations from soil cores.** This approach included a graphical analysis using box and whisker plots with two different grouping combinations of visual NAPL observation classes. In addition, an assessment was

performed to best match the ratio of presence and absence of NAPL observed in soil cores with that observed in in-situ TarGOST readings. This analysis was performed to balance the count of false positives versus false negatives.

3. **General statistical comparison of all ex-situ TarGOST response intervals with corresponding visual NAPL observations from confirmation soil cores.** This process was the same as that performed for the in-situ TarGOST with both a graphical approach with box and whisker plots and a ratio balancing analysis for false positives versus false negatives.

Each of the three approaches was intended to provide a line of evidence in selecting the most representative cutoff value of %RE that distinguishes between NAPL presence and absence.

4.1.1 Visual Comparison

The first approach involved creating images that contained all three types of data: the raw in-situ TarGOST, the visual NAPL observations from the co-located soil cores, and the average ex-situ readings from selected intervals of the confirmation cores. The visual NAPL observations were plotted down the vertical axis of the %RE response in-situ TarGOST logs while the average ex-situ measurements were plotted on top of the in-situ graphs as dots at their respective depths. These plots were then visually assessed and professional judgment was used to determine a cutoff value delineating presence versus absence of NAPL. The plots were assessed for how well the visual and in-situ TarGOST data compared to one another, and how well they both compared to the in-situ TarGOST data.

In general, the visual observations were considered to be the most reliable, and the in-situ data were considered to be accurate when they matched the visual observations and possibly inaccurate when they did not. The ex-situ data were used to verify the visual observations and assess the comparability of the in-situ data. General offset between the datasets was factored into the assessment. In conducting the visual assessment, it was found that the areas where no NAPL was observed in the confirmation core were the easiest to compare with the in-situ TarGOST. Generally, the highest reasonable %RE response in these intervals was chosen as the cutoff between presence and absence of NAPL. Each plot contains an explanation of the selected cutoff value and the cutoff value is projected onto the plot for reference. Figure 4-1 presents TarGOST borings at location 2013-001 as an example of this approach. The selected cutoff values from each plot range from 4%RE to 25%RE, with an average value of 9.5%RE (Appendix C-3).

4.1.2 In-Situ TarGOST Statistical Analysis

The second method for assessing the cutoff %RE included two statistical analyses comparing the visual NAPL observations with the in-situ TarGOST data. Replicate TarGOST probes were included in the analysis as several of the locations selected for confirmation borings were also locations of TarGOST replicates. Raw TarGOST measurements were defined for discrete points at inconsistent intervals. This required post-processing of the data to correlate the visual NAPL observations from the soil core with the TarGOST measurements. Each TarGOST point measurement was individually matched with the corresponding visual NAPL description based on the depth of the point measurement and the visual NAPL interval within which it aligned. TarGOST readings falling within intervals of the core representing “no recovery” were discarded in the analysis. Visual NAPL observation descriptions varied by field logger and therefore were simplified for consistency and ease of analysis. Intervals were often identified with various combinations of descriptions including sheen and staining, coating, or wetting descriptions. NAPL observations were simplified by selecting the most conservative (strongest indicator of NAPL) term for each interval. From least strong to strongest, these were slight sheen, moderate sheen, heavy sheen, oil stained, oil coated, and oil wetted. Descriptions of “product globules” were interpreted as “oil wetted.”

4.1.2.1 Box Plots

Following the processing of the data, the individual %RE response measurements were then grouped into their corresponding NAPL observation classes. Then the statistical program ProUCL was used to generate box and whisker plots of the datasets. These plots show the box including the lower, median, and upper quartiles for each class of NAPL observation in %RE. They also show the whiskers that are extended to the furthest data point that is not categorized as an outlier. It is important to note that in preparation of the plots, ProUCL classifies data a potential outlier when its value is at a distance greater than 1.5 times the interquartile range from the closest end of the box. Two box and whisker plots were generated for the dataset: one with the %RE data divided into all of the possible NAPL classes, and one that compared the datasets indicating the presence and absence of NAPL (Figure 4-2). This plot combines all of the classes indicating NAPL presence into one category, thus eliminating variation in visual interpretation.

A review of the individual NAPL class plots indicates extensive overlap of the %RE quartile ranges between the different classes. As a consequence NAPL observations cannot be correlated with higher in-situ TarGOST response readings to identify areas of the site with greater NAPL impacts.

The plot showing the larger groupings of present and absent NAPL indicate very little overlap between %RE quartile ranges of the two classes (Figure 4-2). Because the two classes are relatively distinct, the NAPL observations coupled with the TarGOST responses can be used to select a %RE that differentiates between the presence and absence of NAPL. From this analysis, the median value for the TarGOST associated with no visible NAPL is 2%RE, while the median value indicating NAPL presence is 10%RE (Figure 4-2). This suggests that NAPL presence/absence cutoff ranges between these two median values.

4.1.2.2 Analysis to Balance False Positives and Negatives

The last approach of assessing the cutoff value with the in-situ dataset was to assess what %RE cutoff resulted in the best match between the in-situ TarGOST and the visual NAPL observations. For this analysis, the dataset with the correlated NAPL observations and individual TarGOST measurements was used. To assess how well the two datasets matched, a range of %REs was applied as potential cutoff values for the in-situ dataset. For each potential cutoff value, all individual TarGOST measurements above the cutoff were coded as “NAPL present” and those below as “NAPL absent.” Then each measurement was compared to the corresponding visual NAPL observation previously matched to the point. The total dataset contained 18,586 individual TarGOST measurements with corresponding visual NAPL observations.

Overall, a high degree of agreement between the two datasets was observed (Figure 4-3 – see middle table). The highest agreement was found for a %RE cutoff range of 5%RE to 27%RE between 80 percent and 83 percent. The %REs with the highest percent agreements were 7%RE, 10%RE, and 13%RE at 82.8, 83.3, and 82.3 percent agreement, respectively. Next, the TarGOST and visual observations that did not match were considered.

There are a number of reasons why the TarGOST and visual observations may not match, including:

- Adjacent borings may be vertically offset if one or both are not plumb with the surface. These offsets can be exaggerated the deeper the boring penetrates into the surface.
- Drill tooling can encounter buried debris or cobbles which may result in angled offset of direct push tooling as the boring is advanced. This may result in significant offset between the TarGOST probe and the soil core at greater depths.
- Small variations in the lithology exist that change the NAPL distribution over small distance intervals. NAPL, especially dense non-aqueous phase liquid (DNAPL), architecture is very sensitive to changes in pore entry pressure, which results in DNAPL pooling on media of lower permeability.
- Verification of NAPL presence is subjective, based on the consistency of observations, both between different core segments and between different logging personnel, and the tendency for NAPL to quickly dissipate from recovered cores in some cases.
- Direct push coring may underestimate NAPL occurrence because of poor sample recovery.
- Potential compression of direct push cores may distort the sampled interval and smear or mobilize NAPL away from the sampled section.

In order to account for these factors, the values that failed to correlate were taken into consideration. The dataset consists of both false negatives (TarGOST measurements which after the selected cutoff was applied indicated no NAPL, while the visual observations indicated NAPL presence) and false positives (TarGOST measurements that indicated NAPL presence, while visual observations indicated NAPL absence). For example, an elevated %RE may be spread across an interval of visual NAPL presence and NAPL absence (such as in 2013T-036 at a depth of 12 to 15 ft bgs [Appendix C-3]) or, conversely, visual observations may indicate NAPL presence where some, but not all, %REs are elevated (such as in 2013T-013 at a depth of 12 to 14.5 ft bgs [Appendix C-3]). While the elevated %RE readings may correctly correspond to the areas of observed NAPL presence, direct correlation by depth results in both false negative and false positive readings. In order to account for this error, selecting a %RE that results in a balance between false negative and false positive readings may introduce the minimum amount of bias to the dataset interpretation. Therefore, a %RE cutoff that achieved the best balance between false negatives and false positives was selected as the optimal %RE cutoff distinguishing between NAPL presence and absence. In the case of the in-situ TarGOST dataset, 7%RE achieved a balance of 9 percent false negatives and 8 percent false positives and thus could be considered the most favorable %RE to compare the in-situ TarGOST with the visual observation dataset and account for dataset limitations (Figure 4-3).

4.1.3 Ex-Situ TarGOST Statistical Analysis

The ex-situ TarGOST dataset and the visual NAPL observations are easier to correlate than the in-situ TarGOST and the visual NAPL observations, since the observations and readings were performed on the same material. This analysis eliminates many of the potential sources of error described above.

The primary limitations remaining when comparing these datasets include the following:

- The subjectivity of visual NAPL presence evaluation based on the consistency of observations and the tendency for NAPL to quickly dissipate from recovered cores in some cases.
- The ex-situ TarGOST measurements are taken on a small subset of the confirmation soil core.
- TarGOST readings were more often performed where NAPL was observed, potentially biasing the dataset toward NAPL presence (42 percent present to 58 percent absent when matched with visual observations).

4.1.3.1 Box Plots

The method for developing the box plots was the same for the ex-situ dataset as for the in-situ dataset described above. Two plots are presented, one of all the NAPL classes and one with only NAPL presence and absence distinguished (Figure 4-4). For this dataset there was better differentiation and less overlap between the different NAPL classes, but still some ambiguity. The strongest NAPL signature, “oil wetted,” corresponded with a median of 37%RE, which was the highest median value. However, “oil staining” had a lower median value at 7%RE than either %REs corresponding to “moderate” or “heavy sheen,” both at 13%RE. The %REs associated with absence of NAPL also showed less data variability than those in the in-situ dataset, which is likely an indication of the sources of error previously listed.

The second plot comparing NAPL presence and absence presents a slightly higher median value indicating NAPL presence at 15%RE, compared with NAPL absence at 2%RE (Figure 4-4). The higher NAPL presence value may be attributed to the dataset bias toward intervals with NAPL compared to the ex-situ dataset.

4.1.3.2 Analysis to Balance False Positives and Negatives

The final analysis based on achieving the best correlation between the two datasets and thereby selecting the optimal cutoff between presence and absence of NAPL was performed in the same manner as that for the in-situ dataset (Figure 4-5). For the ex-situ data, a range of %REs from 4%RE to 27%RE resulted in an agreement between the ex-situ data and the visual NAPL observations ranging from 69 percent to 79 percent. The closest matches were for 4%RE, 5%RE, and 10%RE at 78.2, 79.2, and 78.0 percent, respectively.

The values in disagreement, the false negatives and false positives, were then analyzed for which %RE resulted in the best balance between the two conditions. Of the three %REs that resulted in the highest agreement between the datasets, 5%RE resulted in the closest ratio between the false negatives and false positives at 11 percent and 10 percent, respectively (Figure 4-5).

4.1.4 Inferred NAPL Presence

This section has presented the methods used to evaluate the three TarGOST data sets in an effort to determine transition or cutoff between the presence or absence of NAPL. As described, each of the methods has its limitations, such as reliance on professional judgment, limitation due to core recovery, or sample bias. The conclusions from each method are as follows:

- On visual comparison, the selected cutoff values from each plot range from 4%RE to 25%RE, with an average value of 9.5%RE.
- On in-situ TarGOST statistical analyses:
  - With the graphical box plot for NAPL presence versus absence, the median value for the TarGOST associated with no visible NAPL is 2%RE, while the median value indicating NAPL presence is 10%RE. This suggests that NAPL presence/absence cutoff ranges between these two median values.
  - With the analysis to balance false positives with false negatives, the 7%RE cutoff achieved a balance of 9 percent false negatives and 8 percent false positives and thus could be considered the most favorable %RE to compare the in-situ TarGOST.
- On ex-situ TarGOST statistical analyses:
  - With the graphical box plot for NAPL presence versus absence, the median value for the TarGOST associated with no visible NAPL is 2%RE, while the median value indicating NAPL presence is 15%RE. The higher NAPL presence value compared to the in-situ balancing method may be attributed to the dataset bias toward intervals with NAPL compared to the ex-situ dataset.
  - With the analysis to balance false positives with false negatives, the 5%RE resulted in the closest ratio between the false negatives and false positives at 11 percent and 10 percent.

Based on combined review of the above analyses, a TarGOST %RE response cutoff value between 5%RE and 10%RE can be justifiably selected as representing the presence of NAPL. For the purposes of evaluation of the full TarGOST dataset documented in this technical memorandum, TarGOST responses of 5%RE and greater are conservatively inferred to indicate that NAPL is present at measured locations.

4.2 NAPL Extent and Distribution

Three methods were used to evaluate NAPL extent and distribution throughout the Upland Area: A gross interpolation of shallow and deep maximum %RE responses, mapping with fence diagrams and a Thiessen polygon volume and thickness evaluation. The resulting NAPL extent and distribution is compared against site historical features, potential source areas, and early remedial actions (see Figure 4-6) to provide further insight regarding site conditions.

4.2.1 Gross Interpolation of Shallow and Deep Maximum %RE Responses

This evaluation was utilized during fieldwork to guide selection of additional TarGOST probe locations beyond the 42 initial and secondary borings identified in the QAPP. Described as “heat maps” during the interim meeting between Phase 1 and 2 fieldwork events, this evaluation was prepared by selecting the maximum %RE responses in the shallow zone and at the deeper “near aquitard” zone from the TarGOST logs. These values were then mapped and used to interpolate response fields across the site (Figures 4-7 and 4-8). Following completion of the Phase 2 TarGOST investigation, the maps were updated with the complete dataset and used as a basis to select fence diagram locations and probe locations to include on the fence diagrams.

Because this interpolates a 3-dimensional dataset into two 2-dimensional surfaces, these heat maps should only be considered a gross estimate of NAPL distribution. Observations from the heat maps are as follows:

- In the shallow zone the highest responses emanate from the former retort areas and extend westward toward the former Floating Dock and past the sheet pile wall, eastward but bifurcating to encompass the Naphthalene Block Excavation Area and the Old Sump, and northward to encompass the former Shop Building (see Figure 4-6 for cross-reference with historic features and potential source areas). There is also a high response area centered on the former West Dock, as well as one boring (2013T-152) to the south.

- In the deeper zone near the aquitard the highest responses are concentrated in the central and western portion of the site in the areas of the former lagoon, transfer pit, and retorts with their associated sumps. The eastern half of the site is consistently below the response threshold of 100%RE. High response areas are also present offshore where additional probes were added upon observing high responses along the western edge of the sheet pile wall.
- For both relative elevations the cutoff of the 5%RE as a maximum reading has not been fully delineated to the south, as access in this area is problematic due to underground utilities associated with the treatment facility. The higher response at 2013T-152 is also not delineated due to limited access.

4.2.2 Fence Diagram Evaluation

Fence diagrams were created to evaluate the distribution of NAPL across the Upland Project Area. Figures 4-9 and 4-10 show the locations of the fence diagrams overlaying the shallow zone and near aquitard heat maps as well as potential source areas and prior remediation excavation areas from 1992 through 1994 (digitized from Ecology and Environment, Inc., 1995). Figure 4-11 presents an overview of the information on each of the subsequent diagrams, and Figures 4-12 through 4-20 show LIF signals for selected probing locations along 12 transects. The primary transects (A through F) were chosen such that they radiate outward from a centrally located TarGOST probe location at the site (2013T-005). Three sub-transects stemming from transects D and F were added for greater spatial coverage and to aid in identifying potential flow paths. Transect G was added to evaluate NAPL impacts along the interior perimeter of the sheet pile wall. All LIF response graphs are scaled the same with vertical response grid lines at an interval of 25%RE and a maximum response of 150%RE.

Relevant observations from the TarGOST log fence diagrams are as follows:

- In general NAPL appears to be thickest in the center of the site where greater TarGOST responses are located, then transitions to thinner lenses with lesser responses as the fence diagrams move radially away from the center of the site and potential source areas.
- Beyond the site center and potential sources the NAPL lenses are vertically distributed but not in any obvious patterns with depth. This distribution is likely a result of multiple source areas, preferential pathways associated with interbedded lithologies, and interaction with variable fluid densities resulting from the transition from freshwater to saltwater and operation of the groundwater extraction system. Further evaluation of NAPL distribution relative to site stratigraphy and groundwater elevations is planned once a 3-D geologic model of the site is available.
- Deeper (near aquitard) TarGOST signal detections appear to terminate at or above TarGOST boring refusal depths. In general where comparable lithology is available TarGOST refusal is coincident with or slightly below transition from the Upper Aquifer to the Glacial Till layer. These factors suggest that the glacial till layer is effectively restricting the migration of NAPL to deeper elevations.
- Along the site’s west side and north end, elevated TarGOST readings were measured adjacent to the sheet pile wall at depth at and above the glacial till layer. In these areas the sheet pile wall driven depths are greater than the deepest TarGOST signal detections.

4.2.3 Thiessen Polygon Evaluation

An evaluation to estimate the total volume of NAPL-impacted soil at the site was conducted using the TarGOST response data coupled with a Thiessen polygon analysis. The raw response data from each TarGOST location was first converted from discrete point data to thickness data. This was accomplished by applying each discrete response measurement to the interval represented by the midpoints between each discrete response depth. Once readings were paired with thicknesses instead of discrete depths, the total thickness of specific TarGOST response levels at each location could be summed. For this analysis, the thickness at each location representing a response greater than or equal to 5%RE, 10%RE, 15%RE, 25%RE, 50%RE, and 100%RE were calculated.

The next step of the evaluation required the development of Thiessen polygons represented by the TarGOST locations. The “Create Thiessen Polygons” tool in Spatial Analyst in ArcGIS was used to develop the Thiessen polygon map. The polygons were created from the input point locations of the primary[1] surveyed TarGOST locations. The polygons were created such that any point within each polygon is closer to the associated TarGOST location than any other TarGOST location nearby. Only TarGOST locations within the sheet pile boundary wall were included in the dataset to create the polygons. The polygons created from TarGOST locations not bounded by other exterior TarGOST locations extended beyond the bounds of the sheet pile wall. Therefore, a post-processing step was performed to crop the exterior polygons to the bounds of the sheet pile wall and within approximately 25 feet of the TarGOST locations at the south end of the site. The resulting polygons used in the analysis are shown in Figure 4-21. The area contained within each Thiessen polygon was then calculated using ArcGIS.

The volume of material within each polygon above the response category was determined by multiplying the corresponding Thiessen polygon areas by the summed thickness of readings greater than or equal to the response category. The total volume of soil sampled within the sheet pile wall as calculated from the ground surface to the bottom of all probes was calculated to be 755,018 cubic yards. The total NAPL-impacted volume was estimated by summing the volumes for each response category for all TarGOST locations. There are limitations of this volumetric estimation approach. There is an implicit assumption that the TarGOST NAPL measurements accurately represent the entirety of the associated Thiessen polygon area. This assumption may not be applicable, particularly on the exterior areas of the site, and likely results in an overestimation of NAPL-impacted volumes.

Figure 4-22 and Table 4-1 present the total sampled volume in comparison with the total NAPL-impacted volume for each response category. As observed an increase in the TarGOST response results in a significant reduction in NAPL-impacted response volumes. To support GIS visualization, each TarGOST location volume was determined as a percent of the total NAPL-impacted volume for each response category. This allows for the presentation of the Thiessen polygons color-coded by NAPL-impacted volume of each polygon location to the total NAPL-impacted volume for the site within each response class. Figure 4-23 presents the resulting graphic for the 5%RE response category. (Note: similar graphics for the other response categories are included in Appendix D for further reference.) The 5%RE response category indicates that NAPL is present extensively across the site. However, many of the Thiessen polygons indicate very limited percent of the total volume. For instance 15 of the 128 Thiessen polygons have percent NAPL-impacted volumes at less than 0.1 percent of the total 167,071 cubic yards impacted by NAPL.

In addition to the volumetric analysis, an evaluation of the total summed thickness for each response class were also mapped and color-coded by their corresponding Thiessen polygons (See Appendix D). This simplistic but direct approach for evaluating the TarGOST data includes contributions from all depth intervals greater than the selected response class. Figure 4-24 presents the resulting graphic for the 5%RE response category. Prospective areas for each thickness classification are also provided. As an example 13 of the 128 Thiessen polygons have summed thicknesses greater than 20 feet (the red polygons on Figure 4-24) and encompass a combined area of approximately 1 acre.

Figure 4-25 shows the 5%RE response category color-coded by total summed thickness overlaid with the potential source areas identified in previous site characterization efforts. The thickest accumulations of NAPL-impacted material (greater than 20 feet thick) appear to be concentrated in the center of the site near the Retort area as well as to the east by the Naphthalene Block Excavation Area. Lesser but still significant thickness accumulations appear to be associated with other potential sources such as the Old Sump to the east, the shop building to the north, the sump associated with a concrete pit for an outhouse also to the north, the discharge point from a buried drain to the west, and the former floating dock also to the west.

[1] Replicate locations were not used in the determination of the Thiessen polygon boundaries. However, corresponding replicate data were used in the determination of the volume of NAPL-impacted material and the total length of impacted material in each polygon. Replicate data were integrated by averaging the data from the parent and replicate probes.

4.3 Association of NAPL with Soil Type

Using the confirmation boring data, this section presents a preliminary evaluation of the potential association of NAPL with soil type. This preliminary evaluation assumes that the confirmation borings statistically represent the soil type and NAPL distribution in the Upper Aquifer. To confirm this, further evaluation should be conducted using the 3-D geology and TarGOST model being developed by Sundance once the model files are available for review.

As described in Section 1.2.2, confirmation soil cores were advanced at 20 locations and the soil cores were logged and visually inspected for the presence of NAPL. The confirmation boring locations, presented on Figure 4-26, provide a good spatial coverage of the site. The advancement depth of the 20 confirmation borings varied from 11 to 81.5 feet bgs, with an average advancement depth of 49.5 feet bgs. Of the 1,039.3 total feet advanced, 598.5 feet of soil cores were recovered and logged. Unfortunately the confirmation boring recovery rates were likely limited by heaving sands and soil compression. Compared with the total TarGOST footage at 7,324 feet, the recovered soil from the confirmation borings represents approximately 8 percent of the material in the Upper Aquifer sampled by TarGOST.

Upon review of the boring logs, the soil types observed in the confirmation soil cores are consistent with the lithologies and geologic units identified in previous studies and described in Section 1.2.2.2. Figure 4-27 presents the confirmation boring lithology and NAPL-impacted soil core lengths by historical geologic unit. The first graphic represents the confirmation boring footage by soil type and NAPL absence and presence. The second graphic to the right represents the lithology type as a percent of total recovered confirmation boring footage. The third graphic at the bottom represents the presence of NAPL as a percentage of total NAPL footage observed, segregated by lithologic unit.

Of the 598.5 feet of recovered soil cores, NAPL was observed in 119 feet, or 20 percent of the sampled material. This is generally consistent with the results of the volumetric analysis presented in the previous section for the 5% RE TarGOST response category, where NAPL is considered present in 22% of volume sampled in the Upper Aquifer.

Because potential NAPL migration is partially dependent on capillary forces, the grain size distribution of site soil is expected to influence the distribution of NAPL in the Upper Aquifer. NAPL is expected to migrate primarily within coarse-grained material in response to hydrodynamic and fluid density forces. To evaluate the potential effect of capillary forces, historical lithologic units were regrouped into select USCS classes which are differentiated by grain size distribution. Figure 4-28 presents similar graphics as Figure 4-27, but instead shows the lithology and NAPL-impacted soil core lengths by the selected Unified Soil Classification System (USCS) soil classes. The relative distribution of the selected USCS classes is as follows:

- 65 percent of recovered confirmation boring soil is coarser-grained material consisting of sand (53.2 percent) and sandy gravel to gravel (12.2 percent).
- 25 percent of the recovered confirmation boring soil is silty sand to sandy silt, and is considered a transitional gradational class.
- 9 percent of recovered confirmation boring soil is fine-grained material consisting of silt to clay.

When compared with NAPL presence by USCS class, there is a tendency for NAPL to preferentially inhabit coarser-grained soil as evidenced by the increased percentages of NAPL by soil type relative to the general prevalence of soil type in the Upper Aquifer.

- 81 percent of NAPL was observed in coarser-grained material consisting of sand (66 percent) and sandy gravel to gravel (15 percent).
- 11 percent of NAPL was observed in silty sand to sandy silt.
- 7 percent of NAPL was observed in fine-grained material consisting of silt to clay.

This provides preliminary confirmation of expectations for NAPL distribution based on migration forces. Once available the 3-D geology and TarGOST model will be reviewed and similarly evaluated.

5 Conclusions

This upland investigation included the advancement of 141 TarGOST probes and 20 confirmation borings over two investigation phases. Minor deviations from the QAPP include alteration of the borehole nomenclature and a change in frequency for replicate TarGOST probes and confirmation borings. NAPL mobility analysis (an optional task in the QAPP) was delayed pending further data analysis and consideration. The resulting data presented in this report were evaluated for quality and usability. Conclusions from the quality assurance and quality control review are as follows:

- TarGOST replicate probe results indicate that the TarGOST signal response is reliably reproducible, but subject to inherent variability based on irregular distribution of NAPL, even on a relatively local scale.
- NAPL observations from the soil cores are generally consistent with TarGOST probing results, but tend to exhibit some variability due to the inherent variability of subsurface stratigraphic conditions and inferred NAPL distribution.

The data collected should be interpreted with a view to these constraints, but are otherwise suitable for further data analysis.

The investigation and data evaluation results are presented in Section 4 and include a comparison of TarGOST results to soil core NAPL observations, a summary of NAPL extent and distribution, and the association of NAPL with soil type. Based on the comparison of TarGOST results to soil core NAPL observations, a TarGOST %RE response cutoff value between 5%RE and 10%RE can be justifiably selected as representing the presence of NAPL. For the purposes of evaluating the full TarGOST dataset in this memorandum, TarGOST responses of 5%RE and greater are conservatively inferred to indicate that NAPL is present at measured locations. Of the three methods used to evaluate NAPL extent and distribution, both the gross interpolation and Thiessen polygon evaluation methods suggest that NAPL is present across a wide geographic area of the site. However the fence diagrams and Thiessen polygon volumetric analysis indicate that NAPL is distributed over much more discrete vertical horizons in the subsurface. The evaluation of NAPL association with soil type indicates a tendency for NAPL to preferentially inhabit coarser-grained soil. These observed NAPL characteristics have the potential to affect remedy selection and design by allowing possible compartmentalization of the site for implementation of remedial alternatives.

6 References

CH2M HILL. 1997. *Final Remedial Investigation (RI) Report for the Wyckoff Soil and Groundwater Operable Units, Wyckoff/Eagle Harbor Superfund Site, Bainbridge Island, Washington: Report to EPA Region 10.*

CH2M HILL. 2009. *Soil Boring and Monitoring Well Construction Summary -- Wyckoff/Eagle Harbor Superfund Site.* Prepared for the U.S. Environmental Protection Agency, Region 10. January.

CH2M HILL. 2013a. *Quality Assurance Project Plan, Wyckoff Upland NAPL Investigation, Bainbridge Island, Washington.* Prepared for the U.S. Environmental Protection Agency, Region 10. January.

CH2M HILL. 2013b. *2012 Field Investigation Technical Memorandum, Wyckoff OU-1 Focused Feasibility Study.* Prepared for the U.S. Environmental Protection Agency, Region 10. February.

St. Germain, Randy. 2013. Email communication between Randy St. Germain/Dakota Technologies and Rob Healy/CH2M HILL. April 8, 2013.

Ecology and Environment, Inc. 1995. *Final Removal Report, Wyckoff/Eagle Harbor Superfund Site, TDD T10-9410-016*. Prepared for U.S. Environmental Protection Agency, Region 10.

U.S. Army Corps of Engineers (USACE). 1998. *Off-Shore Field Investigation Report for the Barrier Wall Design Project, Wyckoff Groundwater Operable Unit: Report to EPA Region 10.*

U.S. Army Corps of Engineers (USACE). 2000. *Comprehensive Report, Wyckoff NAPL Field Exploration, Soil and Groundwater Operable Units, Wyckoff/Eagle Harbor Superfund Site, Bainbridge, Island, WA*. May. (99-PP-XX Series Push Probe Sediment Cores).

Tables

TABLE 1-1

Upland Field Investigation Summary

Wyckoff Upland Field Investigation

	Nominal Target Explorations per QAPP	Explorations Completed	
Phase 1 TarGOST Probes (Excluding Replicates) January 14 through February 8, 2013	50	77	2013T-001 through 010, 2013T-012 through 020, 2013T-022, 2013T-024 through 027, 2013T-029 through 037, 2013T-039 through 48, 2013T-050 through 056, 2013T-058 through 074, 2013T-076 through 085.
Phase 2 TarGOST Probes (Excluding Replicates) February 25 through March 22, 2013	50	64	2013T-100 through 163
Total TarGOST Probes	100	141	
TarGOST Field Replicates	10% of TarGOST Probe Locations (up to 10)	5% of TarGOST Probe locations (7)	Phase 1 Replicates (7): 001, 002, 027, 036, 037, 056, 068
Confirmation Soil Cores	10% of TarGOST Probe Locations (up to 10)	14% of TarGOST Probe locations (20)	Phase 1 (10 cores): 2013-SC-001, 002, 006, 036, 041, 045, 046, 055, 068, 072 Phase 2 (10 cores): 2013-SC-013, 014, 054, 070, 101, 106, 119, 127, 152, 155

TABLE 1-2

TarGOST LIF Probe Depths, Surface Elevations, and Coordinates

Wyckoff Upland Field Investigation

TarGOST Probe Number	Date Completed	Depth in Feet Below Ground Surface	Estimated Surface Elevation in Feet (NAVD 88)	State Plane Coordinates (NAD 83)		GPS Data Source
				Northing	Easting	
TarGOST Phase 1						
2013-T-001	1/15/13	50.12	15.598	229424.174	1229067.298	Field Reconfirmed
2013T-001R	1/15/13	45.89	15.670	229426.202	1229068.288	Field Reconfirmed
2013T-002	1/14/13	70.58	15.019	229365.289	1229404.444	Field Reconfirmed
2013T-002R	1/31/13	61.43	15.109	229363.039	1229404.880	Field Reconfirmed
2013T-003	1/14/13	57.84	16.000	229265.666	1229391.798	Field Reconfirmed
2013T-004	1/15/13	57.68	14.761	229390.890	1229260.259	Field Reconfirmed
2013T-005	1/15/13	39.99	15.883	229485.707	1229052.262	Field Reconfirmed
2013T-006	1/15/13	55.16	14.219	229512.162	1229197.727	Field Reconfirmed
2013T-007	1/15/13	64.32	15.640	229589.616	1229265.912	Field Reconfirmed
2013T-008	1/29/13	41.33	15.657	229346.452	1229280.054	Field Reconfirmed
2013T-009	1/30/13	60.19	15.261	229413.408	1229346.016	Field Reconfirmed
2013T-010	1/23/13	81.43	19.293	229473.058	1229400.329	Field Reconfirmed
2013T-012	2/1/13	57.17	15.464	229314.930	1229403.687	Field Reconfirmed
2013T-013	1/23/13	49.77	17.204	229239.153	1229413.555	Field Reconfirmed
2013T-014	2/8/13	32.03	19.341	229318.842	1229148.938	Field Reconfirmed
2013T-015	1/31/13	35.79	14.687	229402.690	1229192.571	Field Reconfirmed
2013T-016	1/25/13	40.83	15.788	229408.846	1229135.492	Field Reconfirmed
2013T-017	1/25/13	32.86	16.182	229388.726	1229057.253	Field Reconfirmed
2013T-018	1/24/13	29.07	16.044	229320.547	1229001.469	Field Reconfirmed
2013T-019	1/23/13	29.91	16.098	229334.225	1228932.310	Field Reconfirmed
2013T-020	1/25/13	32.65	16.041	229378.379	1228993.585	Field Reconfirmed
2013T-022	1/31/13	36.68	14.037	229449.502	1229143.910	Field Reconfirmed
2013T-024	1/22/13	45.54	19.070	229471.997	1228924.046	Field Reconfirmed
2013T-025	1/22/13	53.22	18.127	229551.684	1229001.133	Field Reconfirmed
2013T-026	1/22/13	48.61	15.718	229562.433	1229070.393	Field Reconfirmed
2013T-027	1/24/13	54.13	14.169	229579.049	1229184.548	Field Reconfirmed
2013T-027R	1/24/13	60.73	14.177	229576.610	1229185.873	Field Reconfirmed
2013T-029	1/30/13	61.78	15.824	229484.540	1229306.265	Field Reconfirmed
2013T-030	1/24/13	73.33	15.644	229548.609	1229294.536	Field Reconfirmed
2013T-031	1/24/13	76.51	16.304	229606.238	1229329.517	Field Reconfirmed
2013T-032	1/23/13	79.70	15.836	229658.855	1229307.000	Field Reconfirmed
2013T-033	1/23/13	67.02	14.708	229671.474	1229221.064	Field Reconfirmed
2013T-034	1/22/13	64.28	15.233	229627.376	1229110.234	Field Reconfirmed
2013T-035	1/31/13	44.29	14.143	229433.185	1229223.170	Field Reconfirmed
2013T-036	1/23/13	85.31	17.898	229563.212	1229372.390	Field Reconfirmed
2013T-036R	1/31/13	77.14	17.884	229560.776	1229373.189	Field Reconfirmed
2013T-037	1/21/13	57.90	20.718	229569.697	1228956.946	Field Reconfirmed
2013T-037R	1/22/13	55.43	20.878	229571.633	1228954.990	Field Reconfirmed
2013T-039	1/21/13	70.46	18.239	229710.216	1228962.878	Field Reconfirmed
2013T-040	1/17/13	82.03	21.610	229773.352	1229037.924	Field Reconfirmed
2013T-041	1/16/13	75.08	19.337	229795.266	1229119.480	Field Reconfirmed
2013T-042	1/16/13	77.74	19.615	229796.904	1229184.519	Field Reconfirmed
2013T-043	1/17/13	77.23	19.146	229748.676	1229231.350	Field Reconfirmed
2013T-044	1/16/13	81.72	23.115	229739.385	1229302.432	Field Reconfirmed
2013T-045	1/17/13	85.69	23.333	229666.545	1229339.769	Field Reconfirmed
2013T-046	1/22/13	43.65	18.542	229476.390	1228829.603	Field Reconfirmed
2013T-047	1/21/13	75.61	15.908	229725.011	1229097.024	Field Reconfirmed
2013T-048	1/21/13	63.82	15.334	229710.751	1229148.583	Field Reconfirmed
2013T-050	1/24/13	37.31	18.382	229062.642	1229423.512	Field Reconfirmed
2013T-051	1/24/13	47.99	17.040	229145.242	1229469.804	Field Reconfirmed
2013T-052	1/25/13	70.27	15.033	229675.673	1229251.185	Field Reconfirmed

TABLE 1-2

TarGOST LIF Probe Depths, Surface Elevations, and Coordinates

Wyckoff Upland Field Investigation

TarGOST Probe Number	Date Completed	Depth in Feet Below Ground Surface	Estimated Surface Elevation in Feet (NAVD 88)	State Plane Coordinates (NAD 83)		GPS Data Source
				Northing	Easting	
2013T-053	1/28/13	54.95	14.892	229589.218	1229158.268	Field Reconfirmed
2013T-054	1/28/13	59.56	17.384	229669.220	1229059.951	Field Reconfirmed
2013T-055	1/28/13	69.57	17.925	229726.158	1228992.893	Field Reconfirmed
2013T-056	1/25/13	37.02	15.868	229414.270	1228880.682	Field Reconfirmed
2013T-056R	1/25/13	36.92	15.545	229416.510	1228879.582	Field Reconfirmed
2013T-058	1/25/13	35.42	16.265	229370.400	1228851.351	Field Reconfirmed
2013T-059	1/25/13	28.31	16.273	229306.672	1228914.599	Field Reconfirmed
2013T-060	1/25/13	24.43	17.000	229272.912	1228960.130	Field Reconfirmed
2013T-061	1/28/13	64.06	16.086	229685.561	1229095.909	Field Reconfirmed
2013T-062	1/28/13	51.57	16.117	229648.491	1229156.607	Field Reconfirmed
2013T-063	1/29/13	74.65	17.772	229731.765	1229224.853	Field Reconfirmed
2013T-064	1/29/13	63.90	18.862	229760.763	1229168.012	Field Reconfirmed
2013T-065	1/29/13	69.02	15.959	229757.470	1229088.976	Field Reconfirmed
2013T-066	1/30/13	32.75	18.255	229321.729	1228811.121	Field Reconfirmed
2013T-067	1/30/13	28.75	18.756	229274.622	1228764.370	Field Reconfirmed
2013T-068	1/30/13	25.45	18.989	229236.861	1228805.411	Field Reconfirmed
2013T-068R	2/1/13	25.22	18.975	229237.985	1228804.260	Field Reconfirmed
2013T-069	1/30/13	25.79	18.278	229267.355	1228874.517	Field Reconfirmed
2013T-070	1/30/13	25.62	17.642	229279.729	1228922.217	Field Reconfirmed
2013T-071	1/30/13	17.44	19.822	229190.511	1228709.205	Field Reconfirmed
2013T-072	1/30/13	50.39	15.635	229582.926	1229087.349	Field Reconfirmed
2013T-073	1/31/13	24.92	16.811	229240.592	1229248.126	Field Reconfirmed
2013T-074	1/31/13	43.96	15.923	229261.329	1229354.340	Field Reconfirmed
2013T-076	2/1/13	83.46	18.580	229519.787	1229385.049	Field Reconfirmed
2013T-077	2/1/13	52.55	15.871	229277.154	1229457.716	Field Reconfirmed
2013T-078	2/8/13	23.74	19.581	229222.169	1228966.497	Field Reconfirmed
2013T-079	2/8/13	21.84	19.871	229217.319	1229080.456	Field Reconfirmed
2013T-080	2/8/13	19.45	19.925	229211.496	1229009.874	Field Reconfirmed
2013T-081	2/8/13	25.50	19.359	229285.236	1229050.570	Field Reconfirmed
2013T-082	2/8/13	26.55	19.487	229248.092	1229139.218	Field Reconfirmed
2013T-083	2/8/13	16.06	19.666	229188.204	1228771.742	Field Reconfirmed
2013T-084	2/8/13	23.21	18.907	229212.802	1228902.151	Field Reconfirmed
2013T-085	2/8/13	8.54	19.069	229129.737	1228780.263	Field Reconfirmed
TarGOST Phase 2						
2013T-100	2/27/13	23.95	24.008	229232.036	1228650.592	Field Reconfirmed
2013T-101	3/5/13	25.89	19.088	229303.978	1228643.597	Field Reconfirmed
2013T-102	2/28/13	34.02	16.050	229426.526	1228833.080	Field Reconfirmed
2013T-103	2/28/13	36.49	15.777	229440.013	1228984.866	Field Reconfirmed
2013T-104	2/28/13	45.71	22.646	229511.937	1228895.779	Field Reconfirmed
2013T-105	2/28/13	44.90	14.439	229506.215	1229114.095	Field Reconfirmed
2013T-106	2/28/13	77.90	17.994	229816.536	1229103.804	Field Reconfirmed
2013T-107	3/1/13	80.10	18.596	229823.561	1229147.597	Field Reconfirmed
2013T-108	3/1/13	77.05	18.264	229802.853	1229070.481	Field Reconfirmed
2013T-109	3/1/13	69.34	19.960	229800.808	1229217.340	Field Reconfirmed
2013T-110	3/1/13	70.29	22.786	229712.544	1229295.329	Field Reconfirmed
2013T-111	3/1/13	80.54	19.619	229773.849	1229208.344	Field Reconfirmed
2013T-112	3/1/13	65.75	15.017	229701.413	1229195.557	Field Reconfirmed
2013T-113	3/4/13	6.31	18.033	229030.849	1228697.399	Field Reconfirmed
2013T-114	3/4/13	9.85	17.884	229033.429	1228632.957	Field Reconfirmed
2013T-115	3/4/13	23.87	15.568	229283.810	1228560.359	Field Reconfirmed
2013T-116	3/4/13	32.59	15.072	229358.90	1228606.91	Field Located Using GPS
2013T-117	3/4/13	36.82	14.871	229428.133	1228673.258	Field Reconfirmed

TABLE 1-2

TarGOST LIF Probe Depths, Surface Elevations, and Coordinates

Wyckoff Upland Field Investigation

TarGOST Probe Number	Date Completed	Depth in Feet Below Ground Surface	Estimated Surface Elevation in Feet (NAVD 88)	State Plane Coordinates (NAD 83)		GPS Data Source
				Northing	Easting	
2013T-118	3/4/13	41.33	14.735	229494.17	1228732.51	Field Located Using GPS
2013T-119	3/4/13	47.95	14.326	229526.051	1228780.908	Field Reconfirmed
2013T-120	3/4/13	52.77	14.357	229576.769	1228836.503	Field Reconfirmed
2013T-121	3/5/13	38.51	19.222	229376.200	1228692.744	Field Reconfirmed
2013T-122	3/5/13	36.64	19.207	229421.370	1228759.961	Field Reconfirmed
2013T-123	3/5/13	30.44	20.496	229339.782	1228754.902	Field Reconfirmed
2013T-124	3/5/13	38.09	20.633	229380.717	1228796.318	Field Reconfirmed
2013T-125	3/5/13	30.16	20.502	229286.787	1228709.849	Field Reconfirmed
2013T-126	3/6/13	52.57	12.763	229621.902	1228872.781	Field Reconfirmed
2013T-127	3/6/13	59.37	14.012	229669.700	1228831.150	Field Located Using GPS
2013T-128	3/6/13	61.04	13.935	229619.212	1228773.327	Field Reconfirmed
2013T-129	3/6/13	34.75	11.790	229564.290	1228729.130	Field Located Using GPS
2013T-130	3/6/13	34.07	12.045	229517.630	1228702.170	Field Located Using GPS
2013T-131	3/6/13	40.85	9.292	229450.310	1228633.770	Field Located Using GPS
2013T-132	3/7/13	22.98	18.828	229214.872	1229190.831	Field Reconfirmed
2013T-133	3/7/13	31.55	15.540	229330.418	1229219.530	Field Reconfirmed
2013T-134	3/7/13	30.45	17.552	229209.609	1229311.234	Field Reconfirmed
2013T-135	3/7/13	69.53	16.047	229524.277	1229340.162	Field Reconfirmed
2013T-136	3/7/13	73.93	15.985	229492.535	1229359.217	Field Reconfirmed
2013T-137	3/7/13	72.60	16.110	229583.558	1229301.595	Field Reconfirmed
2013T-138	3/8/13	62.38	16.025	229331.762	1229448.914	Field Reconfirmed
2013T-139	3/8/13	69.40	16.700	229416.291	1229419.409	Field Reconfirmed
2013T-140	3/8/13	63.14	18.932	229665.845	1228980.370	Field Reconfirmed
2013T-141	3/8/13	53.81	17.491	229619.762	1229041.028	Field Reconfirmed
2013T-142	3/8/13	41.69	16.773	229436.373	1228803.423	Field Reconfirmed
2013T-143	3/8/13	52.83	15.324	229321.887	1229376.301	Field Reconfirmed
2013T-144	3/8/13	37.83	15.154	229387.749	1229213.304	Field Reconfirmed
2013T-145	3/11/13	37.28	14.952	229354.284	1229253.699	Field Reconfirmed
2013T-146	3/11/13	49.11	14.188	229542.122	1229174.062	Field Reconfirmed
2013T-147	3/11/13	57.02	16.319	229624.956	1229133.014	Field Reconfirmed
2013T-148	3/11/13	56.67	15.974	229670.924	1229161.171	Field Reconfirmed
2013T-149	3/11/13	41.66	15.714	229450.105	1229083.489	Field Reconfirmed
2013T-150	3/11/13	45.89	16.124	229531.484	1229040.264	Field Reconfirmed
2013T-151	3/11/13	39.22	14.919	229614.765	1229240.478	Field Reconfirmed
2013T-152	3/11/13	23.18	18.362	229179.425	1229188.108	Field Reconfirmed
2013T-153	3/12/13	21.18	23.212	229188.019	1228591.591	Field Reconfirmed
2013T-154	3/12/13	19.91	23.669	229190.033	1228657.771	Field Reconfirmed
2013T-155	3/12/13	71.53	16.938	229755.991	1229130.532	Field Reconfirmed
2013T-156	3/12/13	74.02	18.148	229785.496	1229072.513	Field Reconfirmed
2013T-157	3/12/13	73.79	19.618	229774.266	1229014.329	Field Reconfirmed
2013T-158	3/12/13	68.79	17.762	229711.026	1229072.565	Field Reconfirmed
2013T-159	3/12/13	77.01	22.121	229770.537	1229277.826	Field Reconfirmed
2013T-160	3/13/13	32.79	22.820	229741.907	1229318.723	Field Reconfirmed
2013T-161	3/13/13	61.63	23.246	229471.128	1229266.791	Field Reconfirmed
2013T-162	3/13/13	67.07	16.477	229375.258	1229450.301	Field Reconfirmed
2013T-163	3/13/13	85.58	17.214	229606.890	1229375.669	Field Reconfirmed

Note:

Entries in GPS Data Source Columns are as follows:

“Field Reconfirmed” means the survey crew used the marked borehole location to confirm the GPS coordinates.

“Field Located using GPS” means the locations were not surveyed – either because the markers were washed away before the surveyors arrived (beach locations), or the boreholes were drilled after the survey was completed. The listed coordinates are based on a field reading with the handheld GPS unit.

TABLE 1-3

Confirmation Soil Core Depths, Surface Elevations, and Coordinates

Wyckoff Upland Field Investigation

Soil Core Number	Date Completed	Depth in Feet Below Ground Surface	Estimated Surface Elevation in Feet (NAVD 88)	State Plane Coordinates (NAD 83)		GPS Data Source
				Northing	Easting	
TarGOST Phase 1						
2013-SC-001	2/18/13	35	15.657	229425.211	1229067.314	Field Reconfirmed
2013-SC-002	2/19/13	60	14.991	229363.006	1229403.046	Field Reconfirmed
2013-SC-006	2/25/13	50	14.142	229511.487	1229196.135	Field Reconfirmed
2013-SC-036	2/22/13	64	17.841	229564.613	1229370.296	Field Reconfirmed
2013-SC-041	2/6/13	78	19.258	229794.813	1229118.478	Field Reconfirmed
2013-SC-045	2/8/13	80	23.313	229668.799	1229340.724	Field Reconfirmed
2013-SC-046	2/4/13	42	18.900	229478.926	1228830.471	Field Reconfirmed
2013-SC-055	2/27/13	67.5	17.785	229724.391	1228990.111	Field Reconfirmed
2013-SC-068	2/27/13	23.5	18.977	229239.023	1228805.761	Field Reconfirmed
2013-SC-072	2/26/13	51	15.600	229581.804	1229085.835	Field Reconfirmed
TarGOST Phase 2						
2013-SC-013	3/20/13	52	17.140	229241.207	1229412.811	Field Reconfirmed
2013-SC-014	3/22/13	39.5	19.341	229675.23	1229055.98	Field Located Using GPS; elevation estimated from 2013T-014
2013-SC-054	3/19/13	60	17.350	229671.717	1229058.109	Field Reconfirmed
2013-SC-070	3/20/13	27	17.493	229280.932	1228922.522	Field Reconfirmed
2013-SC-101	3/18/13	27	19.315	229306.216	1228644.157	Field Reconfirmed
2013-SC-106	3/21/13	81.5	17.775	229818.457	1229102.640	Field Reconfirmed
2013-SC-119	3/15/13	30	14.138	229526.912	1228779.339	Field Reconfirmed
2013-SC-127	3/14/13	63	13.244	229668.224	1228836.380	Field Reconfirmed
2013-SC-152	3/15/13	28	18.747	229177.426	1229188.511	Field Reconfirmed
2013-SC-155	3/19/13	69.3	16.914	229756.411	1229128.685	Field Reconfirmed

Note:

Entries in GPS Data Source column are as follows:

“Field Reconfirmed” means the survey crew used the marked borehole location to confirm the GPS coordinates.

“Field Located using GPS” means the locations were not surveyed – either because the markers were washed away before the surveyors arrived (beach locations), or the boreholes were drilled after the survey was completed. The listed coordinates are based on a field reading with the handheld GPS unit.

TABLE 3-1

Comparison of TarGOST and Soil Core NAPL Indicators

Wyckoff Upland Field Investigation

Table entries indicate number of visual NAPL occurrences by soil geologic unit

TarGOST Probe/ Soil Core	Approximate Depth Zones with Proximal Visible NAPL[1]	Depth Zones with Poorly-Correlated Visible NAPL[1] and TarGOST NAPL indicators
Phase 1		
2013T-001/001R 2013-SC-001	4.0-5.4 8.0-10.0 12.0-12.4 16.0-18.8 20.0-21.9 24.0-26.4 28.7-29.9 32.0-34.5	None Identified
2013T-002/002R 2013-SC-002	8.5 9.0 14.1-15.8 16.0-21.8 26.6-27.0 28.0-29.0	36.6-26.8 feet: visible NAPL but TarGOST signals at background
2013T-006 2013-SC-006	13.0-13.3 13.8-14.8 16.9-17.1 17.9-18.0 20.0-22.3 24.0-28.0 30.3-30.4	None Identified
2013T-036/036R 2013-SC-036	12.0-12.4 14.0-14.05 18.1-18.2 18.4-18.6 36.0-37.1	None Identified
2013T-041 2013-SC-041	66.2-66.5	None Identified
2013T-045 2013-SC-045	15.0-18.9 20.9-24.5 27.0-27.4	None Identified
2013T-046 2013-SC-046	29.2-30.0 31.1 33.0 35.0-37.0	None Identified
2013T-055 2013-SC-055	60.6-61.5	None Identified
2013T-068/068R 2013-SC-068	None	None Identified
2013T-072 2013-SC-072	9.0-9.9 12.0-13.6 16.2-16.3 20.0-20.3 36.6 37.0-37.8 38.7-.8.9 40.7-40.9 41.0-43.6 44.9-45.0 48.0-48.75	20.0-20.3: visible NAPL but TarGOST signals at background
Phase 2		
2013T-013	13.4-13.6	None Identified

TABLE 3-1

Comparison of TarGOST and Soil Core NAPL Indicators

Wyckoff Upland Field Investigation

Table entries indicate number of visual NAPL occurrences by soil geologic unit

TarGOST Probe/ Soil Core	Approximate Depth Zones with Proximal Visible NAPL[1]	Depth Zones with Poorly-Correlated Visible NAPL[1] and TarGOST NAPL indicators
2013-SC-013		
2013T-014 2013-SC-014	21.25-21.3	None Identified
2013T-054 2013-SC-054	45.8-46.0 56.3-56.6	17.1-17.2 feet: moderate TarGOST signals but visible NAPL absent 45.8-45.9 feet: visible NAPL but TarGOST signals at background
2013T-070 2013-SC-070	17.5-17.8	None Identified
2013T-101 2013-SC-101	18.5-18.8 21.0-21.2 21.9-22.0	None Identified
2013T-106 2013-SC-106	72.0-73.2	None Identified
2013T-119 2013-SC-119	28.2-28.3	None Identified
2013T-127 2013-SC-127	20.5-20.8 24.0-24.4 49.5-50.5	None Identified
2013T-152/152v2 2013-SC-152	None	6.0-6.2 and 8.5-8.6 feet: moderate TarGOST signals but visible NAPL absent
2013T-155 2013-SC-155	9.0-9.7 20.5-20.8 24.0-24.3 56.5-56.6	None Identified

Note:

[1]NAPL Indicators: oil-coating, oil-wetting, and product globules (excludes sheen). NAPL indicators are coincident with, or present just above or below TarGOST signal zone(s).

TABLE 4-1

Preliminary NAPL Impacted Volumetric Analysis - Upland Area Behind Sheet Pile Wall Only

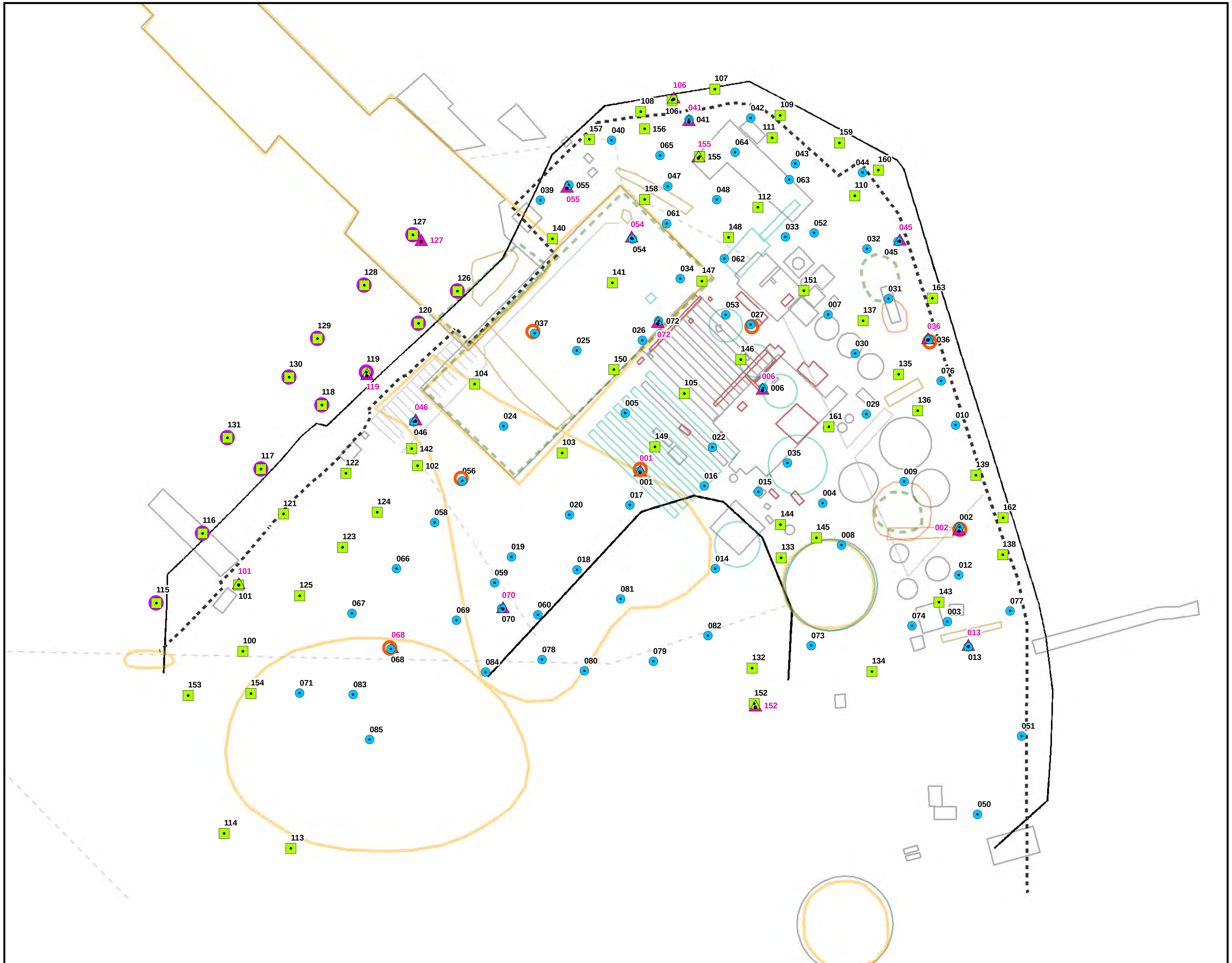
Wyckoff Upland Field Investigation

Volume Sampled	5% RE	10% RE	15% RE	25% RE	50% RE	100% RE	Units
755,018	167,071	109,069	82,563	52,777	21,739	7,109	Cubic Yards
100%	22%	14%	11%	7%	3%	1%	Percent of Volume Sampled

Note:

The raw response data from each TarGOST reading was converted from a discrete elevation to a thickness interval. Each discrete response measurement was applied to the interval represented by the midpoints between each discrete response depth. For example, for paired depths (Xi) and responses (Yi), (X1, Y1), (X2, Y2), and (X3, Y3), response Y1 at the top of the boring would apply to interval 0 to (X1+X2)/2, Y2 would apply to the interval (X1+X2)/2 to (X2 + X3)/2, and so on. The interval was then converted to a thickness corresponding to each reading.

Figures



LEGEND

TarGOST Location and Phase

- Phase 1 TarGOST
- Phase 2 TarGOST
- Replicate TarGOST
- West Beach TarGOST Location
- Confirmation Boring
- Historic Features
- Historic Features Identified from 1917 Sandborn Map
- Potential Primary NAPL Sources (Sumps, Trenches, and other features with observed contamination)
- Potential Secondary NAPL Source Areas
- Trenching and other features of interest identified in April 1989 Map
- Site Remediation Excavation Performed in 1992 through 1994
- Bulk Head Prior to Current Sheet Pile Wall
- Current Sheet Pile Wall

Sources:
Bulk Head Prior to Current Sheet Pile Wall
digitized from current sheet pile wall design drawings
(USACE, 2000)
Some sumps and trenches were digitized from
"Figure 1 Site Location" (Environment and Ecology, 1995)
Sumps and Trenches were digitized from
"Figure B Area 1 Trenches and Sumps";
"Figure C Area 2 Drums, Sumps, 7 Tanks"; "Figure D
Area 3 Containers, Drums, Sumps, Tanks & Trenches"
(Environment and Ecology, 1995)
Secondary NAPL Source Locations digitized from
"Figure 2-1 Wycoff Site Vicinity Map" (CH2M HILL, 1993)
Trenching observations digitized from 1989 hand markup.
Prioritizing of source areas conducted 2012.
Prior remediation excavation areas from 1992 through 1994
digitized from Ecology and Environment, Inc., 1995.

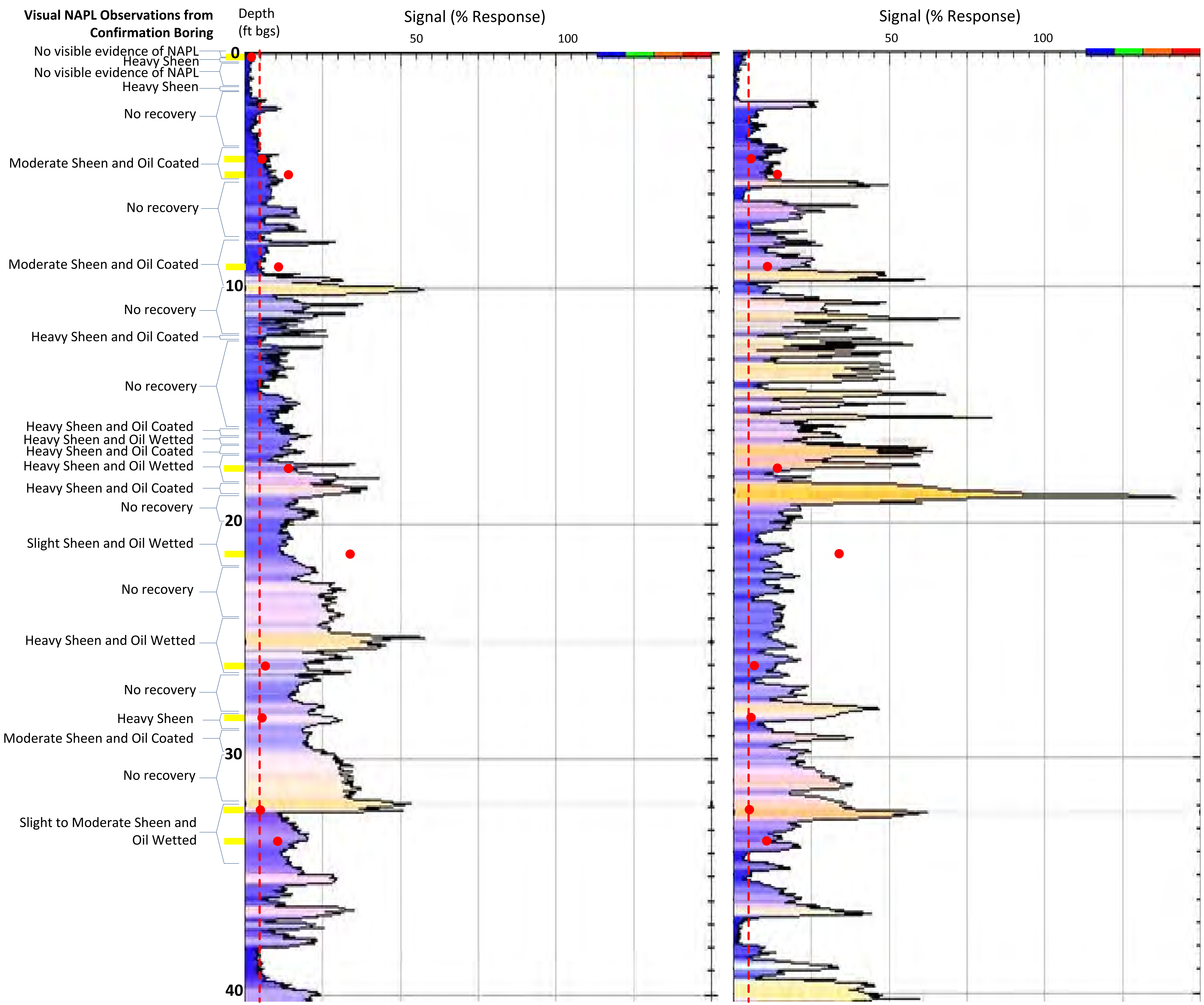
N

0 60 120 240 Feet

Figure 1-1
TarGOST Field Investigation Locations
Wyckoff Upland Field Investigation
Wyckoff/Eagle Harbor Superfund Site

C:\USERS\GGEE\DOCUMENTS\GIS\WYCKOFF\MAPFILES\2013\FIELD INVESTIGATION SUMMARY MEMO\FIGURE1-1_TARGOST_P1_P2.MXD GGEE 6/25/2013 12:36:41 PM

TarGOST Confirmation Boring 2013SC-001 and 001R



LEGEND

In-Situ TarGOST Measurements

In-situ TarGOST response graphs are shown as the base of these figures. The TarGOST graphs shown correspond to the colocated confirmation soil cores.

Ex-situ TarGOST Measurements

Depth interval of ex-situ TarGOST measurement performed on soil core

Approximate average value for of %RE response for ex-situ TarGOST interval

Visual NAPL Observations

Visual observation of NAPL in the confirmation soil cores is shown with depth along the left border of the co-located in-situ TarGOST graphs.

Interpretation

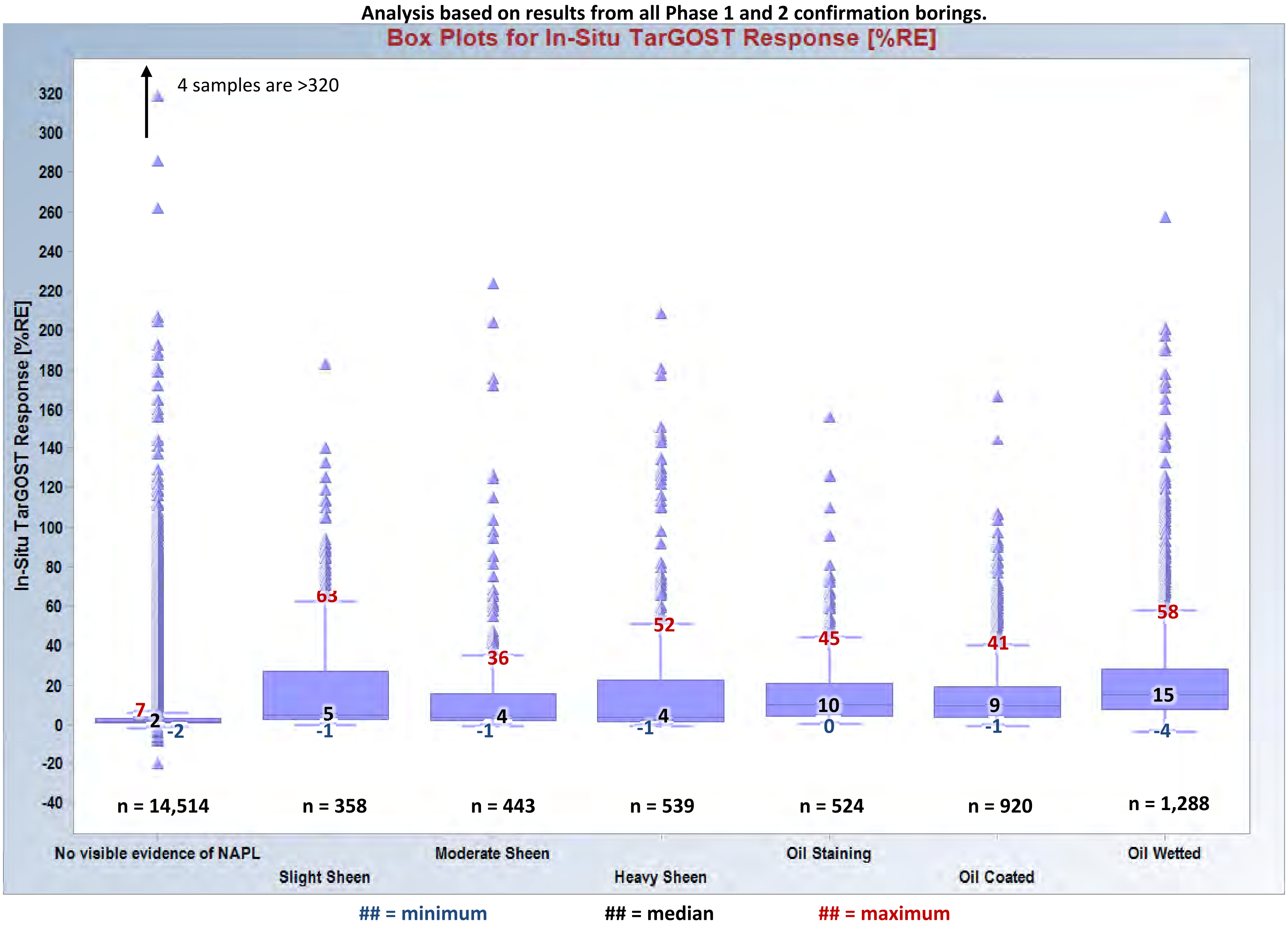
Selected ≥%RE indicating NAPL presence

≥%RE Chosen to Indicate NAPL Presence = 5

This value was chosen based on the top 2 feet of the log. This is the only portion of the log which had intervals of no visible NAPL. The rest of the visual observations all had some indication of NAPL presence. Though some portions of the top of the log still include sheen at very low %RE values, a more conservative value of 5%RE was chosen to indicate NAPL presence.

Figure 4-1
Example Visual NAPL Evaluation
Wyckoff Upland Field Investigation
Wyckoff/Eagle Harbor Superfund Site

A. **TarGOST Responses Grouped by All Visual NAPL Classes**



B. **TarGOST Responses Grouped by Presence or Absence of NAPL**
(All positive identification categories above combined)

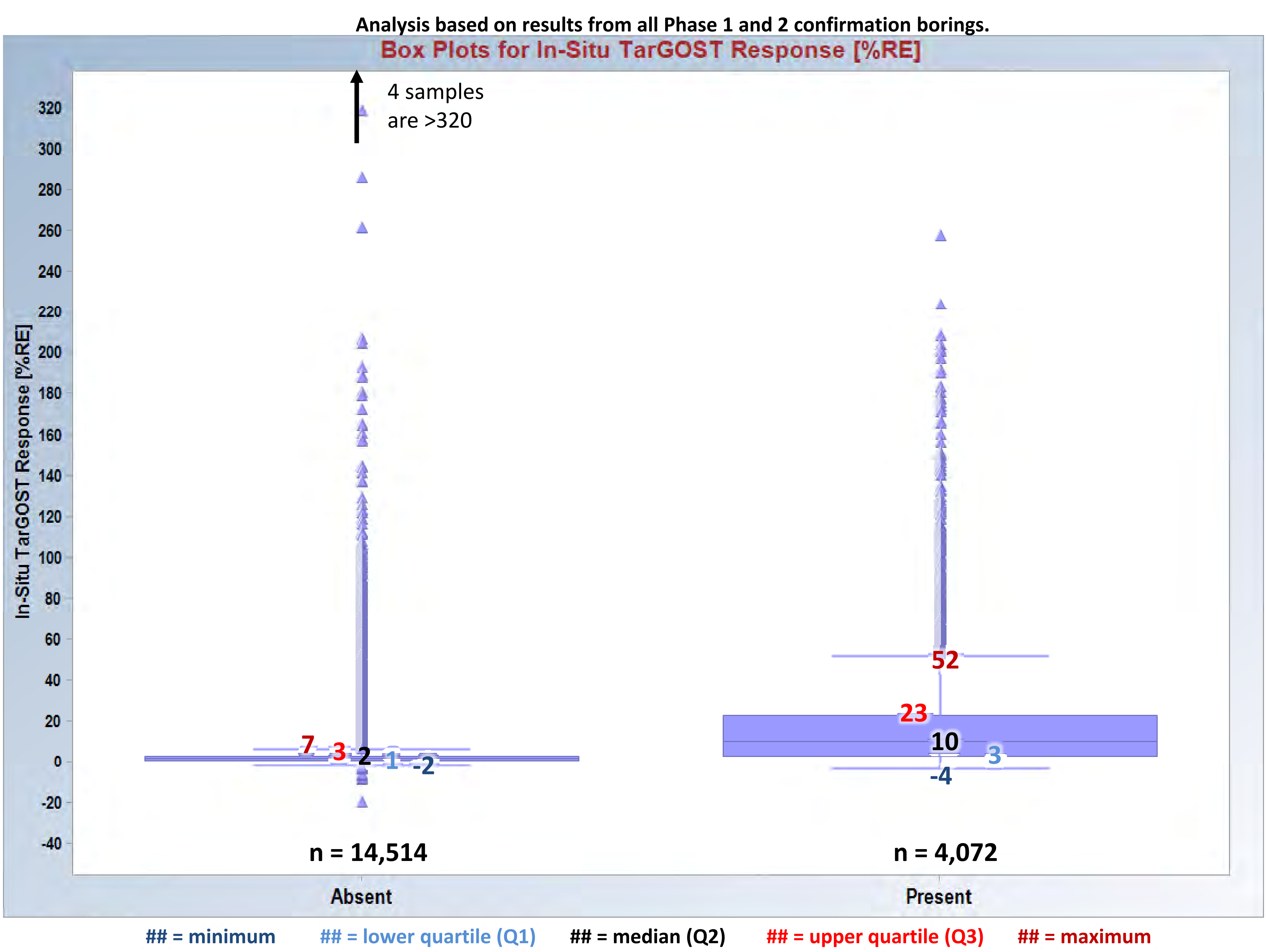


Figure 4-2
Box Plots of In-Situ TarGOST Response [%RE] Grouped by Visual NAPL
Observations in Co-Located Confirmation Borings
Wyckoff Upland Field Investigation
Wyckoff/Eagle Harbor Superfund Site

	Comparison of In-Situ TarGOST to Visual Observations (Count of TarGOST readings)	Cutoff TarGOST Response [%RE] between presence and absence of NAPL					
		5%	**7%**	**10%**	**13%**	**20%**	**27%**
	NAPL Present in Both	2,683	2,439	2,097	1,725	1,172	853
	NAPL Absent in Both	12,346	12,946	13,376	13,577	13,804	13,950
False Negative	NAPL Absent in TarGOST, Present in Visual Observations	1,389	1,633	1,975	2,347	2,900	3,219
False Positive	NAPL Present in TarGOST, Absent in Visual Observations	2,168	1,568	1,138	937	710	564
	Total	**18,586**	**18,586**	**18,586**	**18,586**	**18,586**	**18,586**

	Comparison of In-Situ TarGOST to Visual Observations (Percent)	Cutoff TarGOST Response [%RE] between presence and absence of NAPL					
		5%	**7%**	**10%**	**13%**	**20%**	**27%**
	NAPL Present in Both	14%	13%	11%	9%	6%	5%
	NAPL Absent in Both	66%	70%	72%	73%	74%	75%
	Agreement	80.9%	82.8%	83.3%	82.3%	80.6%	79.6%
False Negative	NAPL Absent in TarGOST, Present in Visual Observations	7%	9%	11%	13%	16%	17%
False Positive	NAPL Present in TarGOST, Absent in Visual Observations	12%	8%	6%	5%	4%	3%
	Disagreement	19.1%	17.2%	16.7%	17.7%	19.4%	20.4%

Circled values show the optimal %RE cutoff between presence and absence of NAPL for acheiving agreement in between the in-situ TarGOST and the visual NAPL observations as well as the best balance between false positives and false negatives. Selecting the %RE that acheives the best balance prevents introducing bias to the dataset as many factors may prevent a perfect match between in-situ TarGOST readings and colocated visual observation of confirmation borings.

Figure 4-3

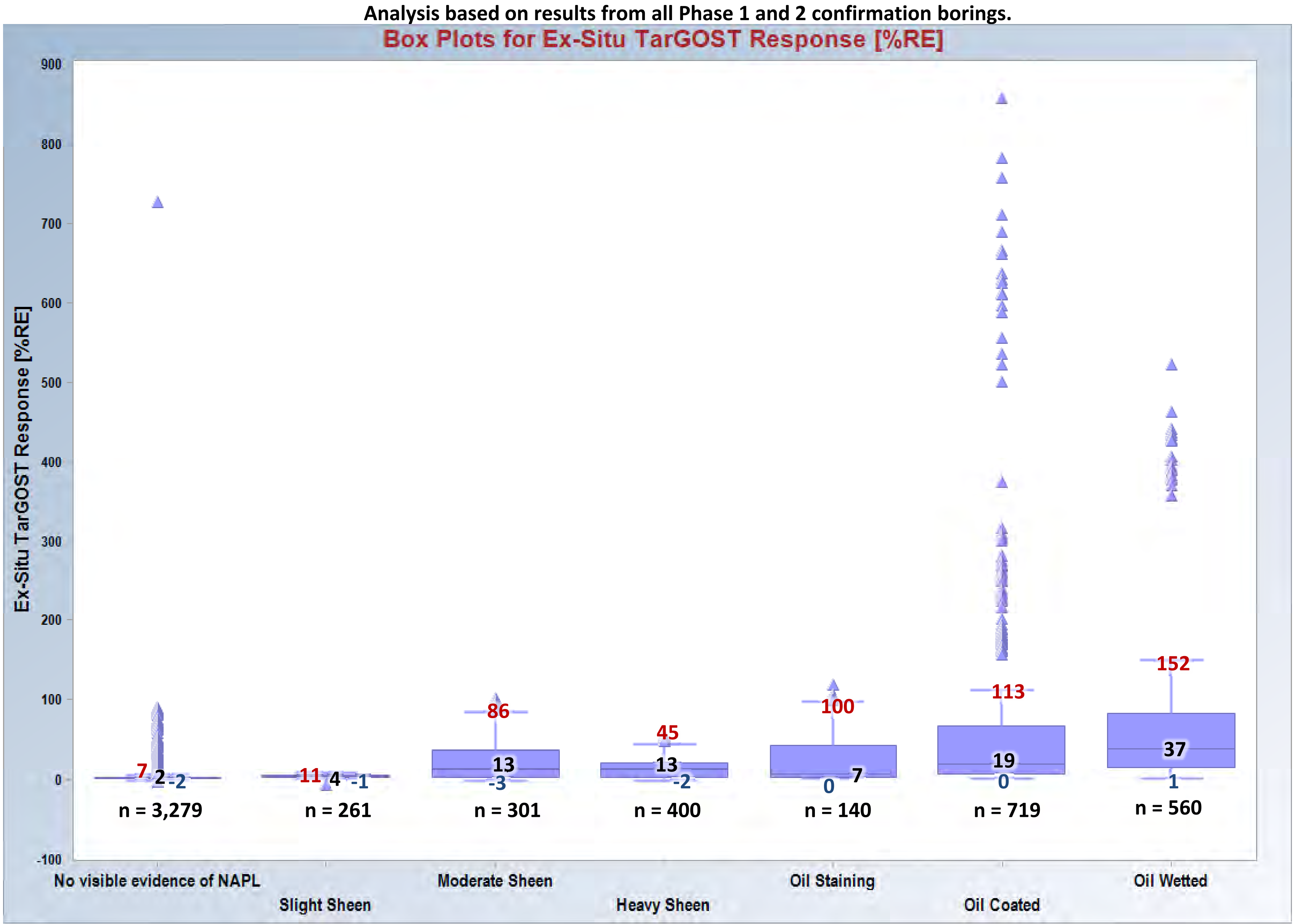
In-Situ TarGOST Statistical Comparison with Co-Located Visual NAPL Observations from Confirmation Boring Logs in Order to Select Best %RE indicating Cutoff between Presence and Absence of NAPL

Wyckoff Upland Field Investigation

Wyckoff/Eagle Harbor Superfund Site

A. **TarGOST Responses Grouped by All Visual NAPL Classes**

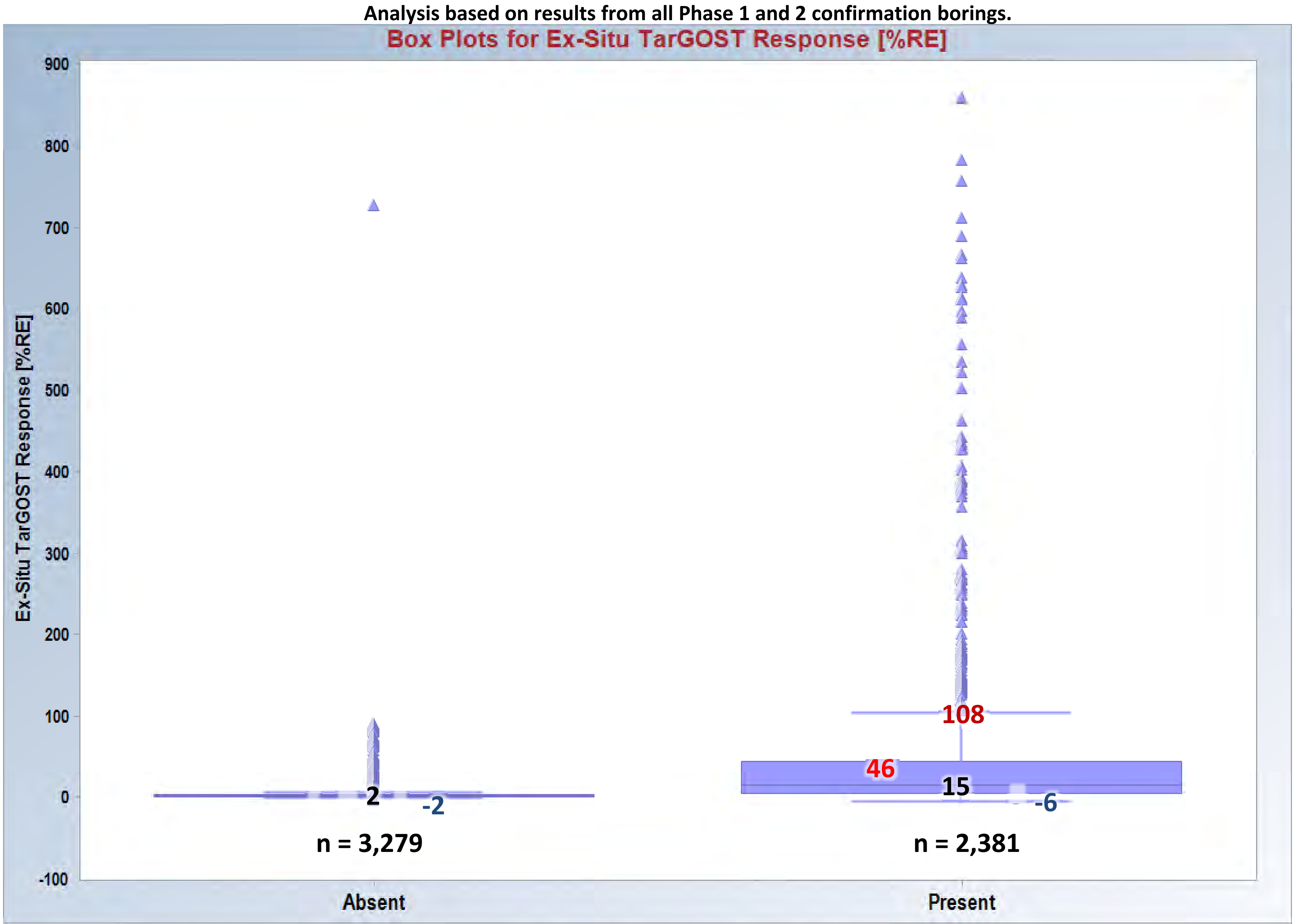
Analysis based on results from all Phase 1 and 2 confirmation borings.



= minimum ## = median ## = maximum

B. **TarGOST Responses Grouped by Presence or Absence of NAPL**
(All positive identification categories above combined)

Analysis based on results from all Phase 1 and 2 confirmation borings.



= minimum ## = lower quartile (Q1) ## = median (Q2) ## = upper quartile (Q3) ## = maximum

Figure 4-4
Box Plots of Ex-Situ TarGOST Response [%RE] Grouped by Visual NAPL Observations in Co-located Confirmation Borings
Wyckoff Upland Field Investigation
Wyckoff/Eagle Harbor Superfund Site

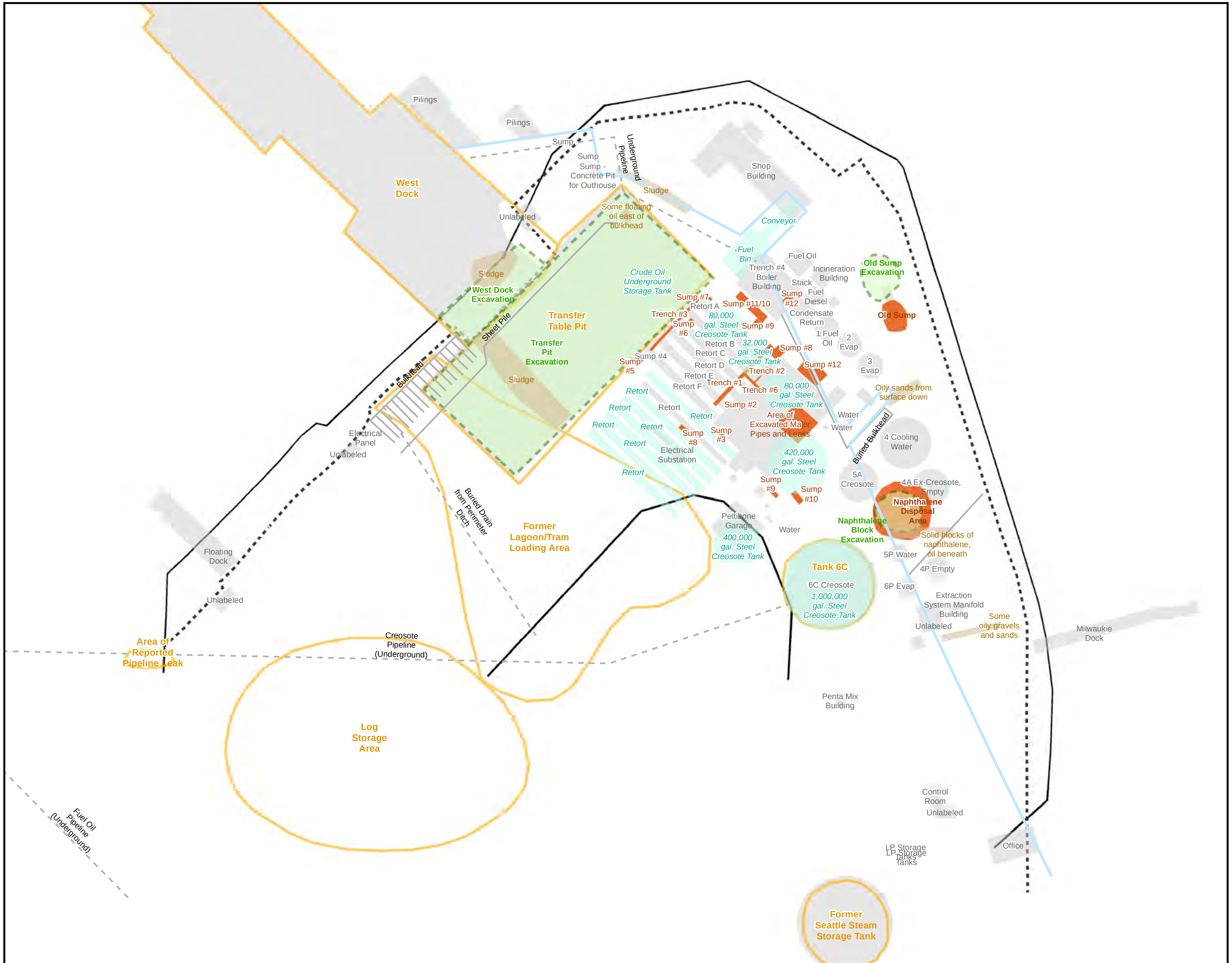
	Comparison of Ex-Situ TarGOST to Visual Observations (Number of TarGOST readings)	Cutoff TarGOST Response [%RE] between presence and absence of NAPL					
		4%	**5%**	**7%**	**10%**	**20%**	**27%**
	NAPL Present in Both	1,905	1,771	1,552	1,433	969	840
	NAPL Absent in Both	2,521	2,712	2,863	2,931	3,023	3,092
False Negative	NAPL Absent in TarGOST, Present in Visual Observations	496	630	849	968	1,432	1,561
False Positive	NAPL Present in TarGOST, Absent in Visual Observations	738	547	396	328	236	167
	Total	**5,660**	**5,660**	**5,660**	**5,660**	**5,660**	**5,660**

	Comparison of Ex-Situ TarGOST to Visual Observations (Percent)	Cutoff TarGOST Response [%RE] between presence and absence of NAPL					
		4%	**5%**	**7%**	**10%**	**20%**	**27%**
	NAPL Present in Both	34%	31%	27%	25%	17%	15%
	NAPL Absent in Both	45%	48%	51%	52%	53%	55%
	Agreement	78.2%	79.2%	78.0%	77.1%	70.5%	69.5%
False Negative	NAPL Absent in TarGOST, Present in Visual Observations	9%	11%	15%	17%	25%	28%
False Positive	NAPL Present in TarGOST, Absent in Visual Observations	13%	10%	7%	6%	4%	3%
	Disagreement	21.8%	20.8%	22.0%	22.9%	29.5%	30.5%

Circled values show the optimal %RE cutoff between presence and absence of NAPL for acheiving agreement in between the en-situ TarGOST and the visual NAPL observations as well as the best balance between false positives and false negatives. Selecting the %RE that acheives the best balance prevents introducing bias to the dataset as many factors may prevent a perfect match between ex-situ TarGOST readings and co-located visual observation of confirmation borings.

Figure 4-5

Ex-Situ TarGOST Statistical Comparison with Co-Located Visual NAPL Observations from Confirmation Boring Logs in Order to Select Best %RE indicating Cutoff between Presence and Absence of NAPL



LEGEND

- Historic Features
- Historic Features Identified from 1917 Sandborn Map
- Site Remediation Excavation Performed in 1992 through 1994
- Potential Primary NAPL Sources (Sumps, Trenches, and other features with observed contamination)
- Potential Secondary NAPL Source Areas
- Trenching and other features of interest identified in April 1989 Map
- Facility Shoreline as of 1917
- Bulk Head Prior to Current Sheet Pile Wall
- Current Sheet Pile Wall

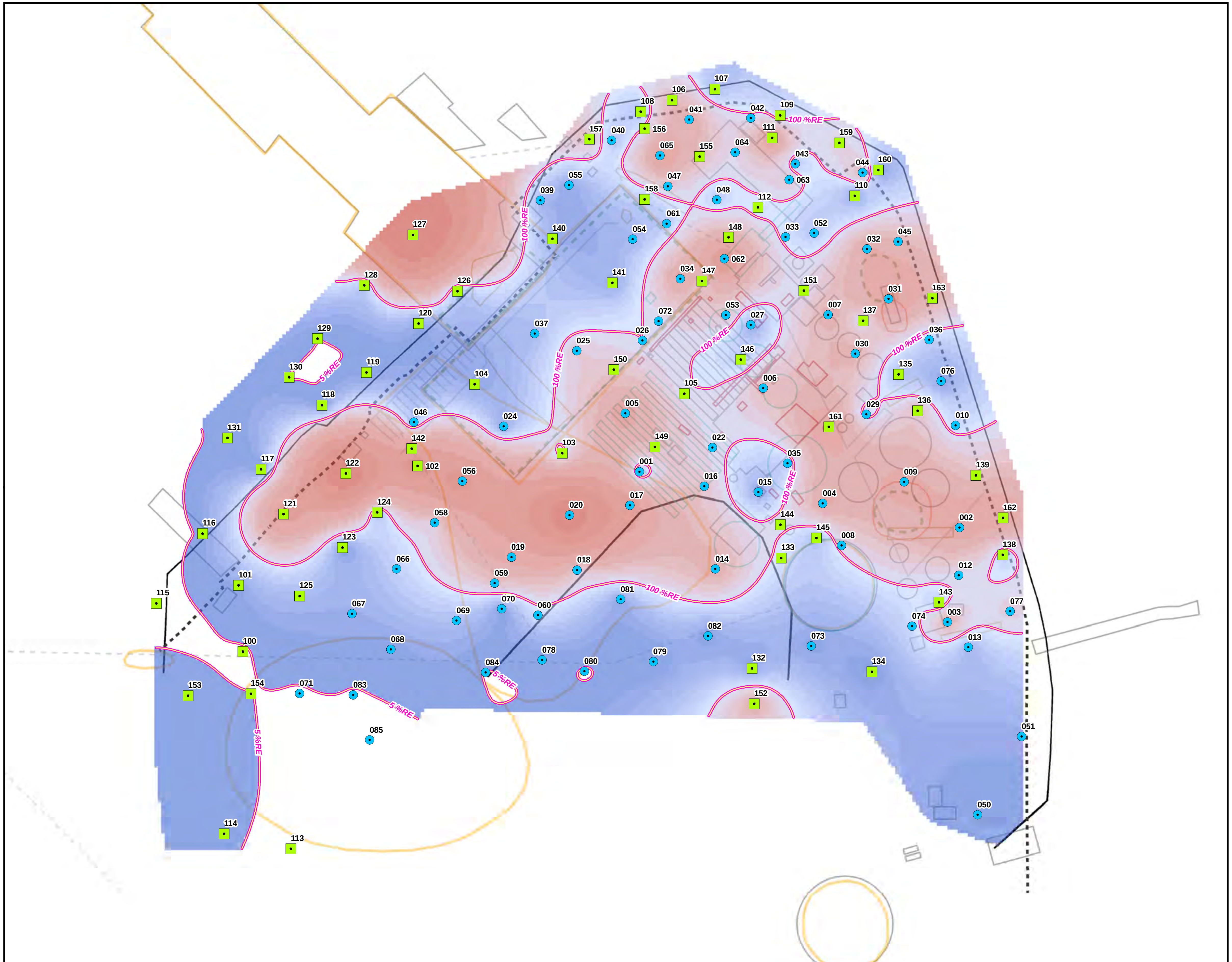
Sources:
Bulk Head Prior to Current Sheet Pile Wall digitized from current sheet pile wall design drawings (USACE, 2000)
Some sumps and trenches were digitized from "Figure 1 Site Location" (Environment and Ecology, 1995)
Sumps and Trenches were digitized from "Figure B Area 1 Trenches and Sumps"; "Figure C Area 2 Drums, Sumps, 7 Tanks"; "Figure D Area 3 Containers, Drums, Sumps, Tanks & Trenches" (Environment and Ecology, 1995)
Secondary NAPL Source Locations digitized from "Figure 2-1 Wycoff Site Vicinity Map" (CH2M HILL, 1993)
Trenching observations digitized from 1989 hand markup.
Prioritizing of source areas conducted 2012.

N

0 50 100 200 Feet

Figure 4-6
Potential Source Areas and Site Features
Wyckoff Upland Field Investigation
Wyckoff/Eagle Harbor Superfund Site

C:\USERS\GGEE\DOCUMENTS\GIS\WYCKOFF\MAPFILES\2013\FIELD INVESTIGATION SUMMARY MEMO\FIGURE1-2_SOURCEAREAS.MXD GGEE 6/5/2013 4:07:14 PM



LEGEND

Maximum %RE Contours of 5% and 100%

Maximum %RE Response - Shallow Zone

- Low: -11%
- Mid: 100%
- High: 1,515%

TarGOST Location and Phase

- Phase 1 TarGOST
- Phase 2 TarGOST
- Confirmation Boring
- Historic Features
- Historic Features Identified from 1917 Sandborn Map
- Site Remediation Excavation Performed in 1992 through 1994
- Potential Primary NAPL Sources (Sumps, Trenches, and other features with observed contamination)
- Potential Secondary NAPL Source Areas
- Trenching and other features of interest identified in April 1989 Map
- Bulk Head Prior to Current Sheet Pile Wall
- Current Sheet Pile Wall

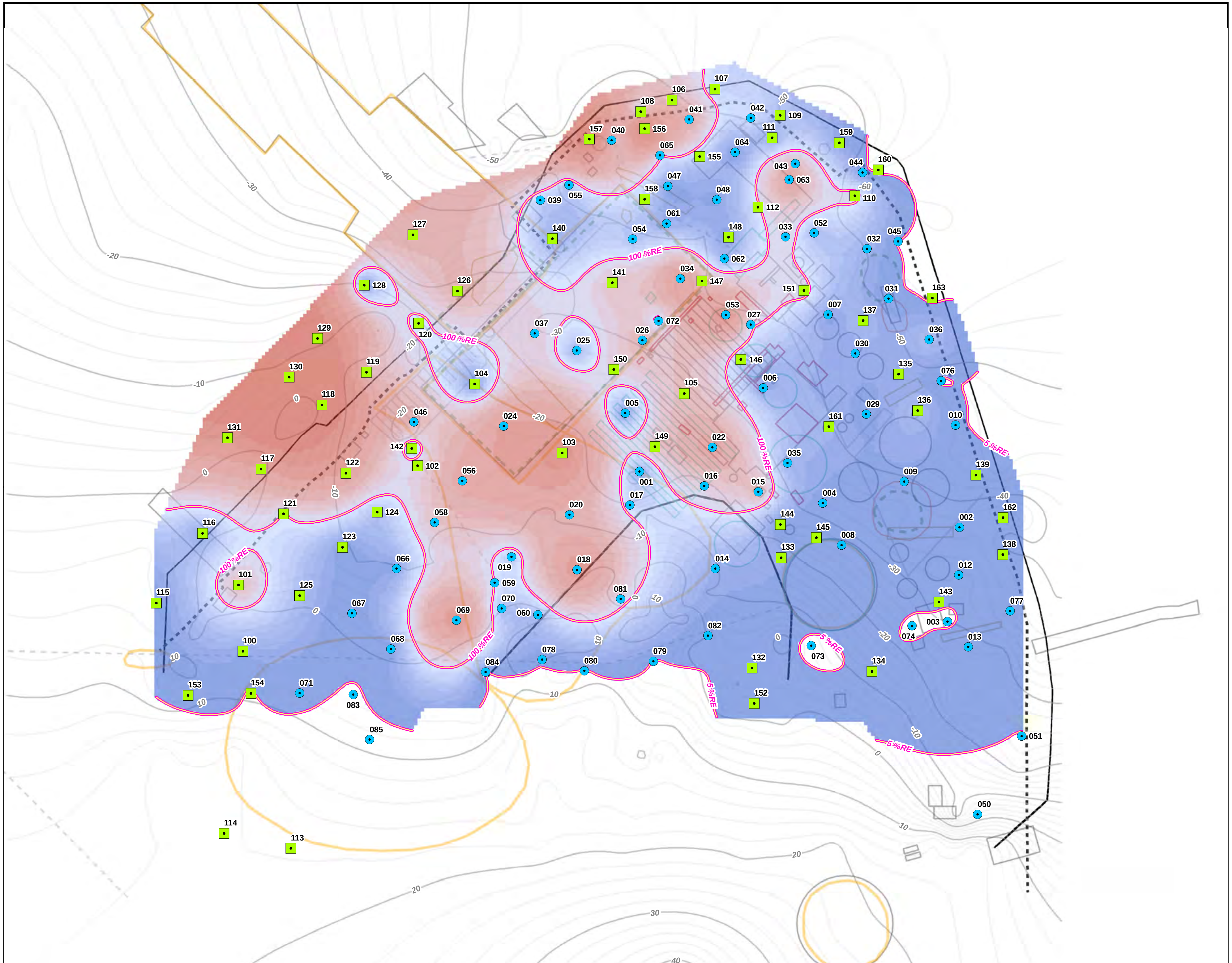
Sources:
Bulk Head Prior to Current Sheet Pile Wall digitized from current sheet pile wall design drawings (USACE, 2000)
Some sumps and trenches were digitized from "Figure 1 Site Location" (Environment and Ecology, 1995)
Sumps and Trenches were digitized from "Figure B Area 1 Trenches and Sumps"; "Figure C Area 2 Drums, Sumps, 7 Tanks"; "Figure D Area 3 Containers, Drums, Sumps, Tanks & Trenches" (Environment and Ecology, 1995)
Secondary NAPL Source Locations digitized from "Figure 2-1 Wycoff Site Vicinity Map" (CH2M HILL, 1993)
Trenching observations digitized from 1989 hand markup.
Prioritizing of source areas conducted 2012.
Prior remediation excavation areas from 1992 through 1994 digitized from Ecology and Environment, Inc., 1995.

N

0 60 120 240 Feet

Figure 4-7
Phase 1 and 2 TarGOST Results
Maximum %RE Response - Shallow Zone
Wyckoff Upland Field Investigation
Wyckoff/Eagle Harbor Superfund Site

C:\USERS\GGEE\DOCUMENTS\GIS\WYCKOFF\MAPFILES\2013\FIELD INVESTIGATION SUMMARY MEMO\FIGURE4-7_SHALLOWMAXRESPONSE_V2.MXD GGEE 6/25/2013 12:55:46 PM



LEGEND

Maximum %RE Contours of 5% and 100%

Maximum %RE Response - Near Aquitard

Low: -11%

Mid: 100%

High: 1,515%

TarGOST Location and Phase

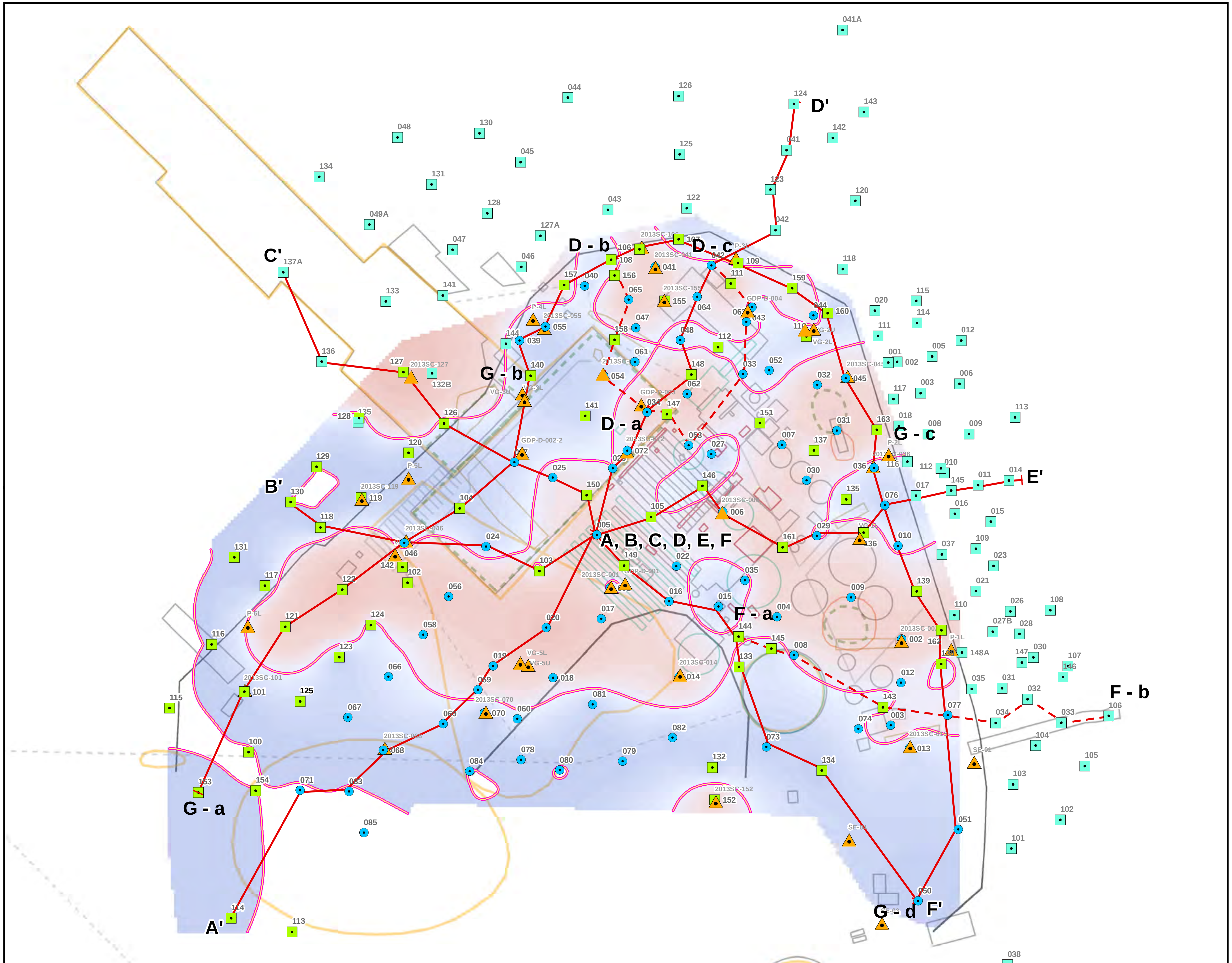
- Phase 1 TarGOST
- Phase 2 TarGOST
- Confirmation Boring
- Trenching and other features of interest identified in April 1989 Map
- Historic Features Identified from 1917 Sandborn Map
- Site Remediation Excavation Performed in 1992 through 1994
- Potential Primary NAPL Sources (Sumps, Trenches, and other features with observed contamination)
- Potential Secondary NAPL Source Areas
- Historic Features
- Bulk Head Prior to Current Sheet Pile Wall
- Current Sheet Pile Wall
- Aquitard Surface Elevation (ft MLLW) 10 ft CI
- Aquitard Surface Elevation (ft MLLW) 2 ft CI

Sources:
Bulk Head Prior to Current Sheet Pile Wall digitized from current sheet pile wall design drawings (USACE, 2000)
Some sumps and trenches were digitized from "Figure 1 Site Location" (Environment and Ecology, 1995)
Sumps and Trenches were digitized from "Figure B Area 1 Trenches and Sumps"; "Figure C Area 2 Drums, Sumps, 7 Tanks"; "Figure D Area 3 Containers, Drums, Sumps, Tanks & Trenches" (Environment and Ecology, 1995)
Secondary NAPL Source Locations digitized from "Figure 2-1 Wycoff Site Vicinity Map" (CH2M HILL, 1993)
Trenching observations digitized from 1989 hand markup.
Prioritizing of source areas conducted 2012.
Prior remediation excavation areas from 1992 through 1994 digitized from Ecology and Environment, Inc., 1995.

0 60 120 240 Feet

Figure 4-8
Phase 1 and 2 TarGOST Results
Maximum %RE Response - Near Aquitard
Wyckoff Upland Field Investigation
Wyckoff/Eagle Harbor Superfund Site

C:\USERS\GGEE\DOCUMENTS\GIS\WYCKOFF\MAPFILES\2013\FIELD INVESTIGATION SUMMARY MEMO\FIGURE4-8_RESPONSEATAQUITARD_V2.MXD GGEE 6/25/2013 12:56:45 PM



LEGEND

Maximum %RE Contours of 5% and 100%

Maximum %RE Response - Shallow Zone

Low: -11%

Mid: 100%

High: 1,515%

Fence Diagram Location, dashed line indicates sub-location

TarGOST Location and Phase

Phase 1 TarGOST

Phase 2 TarGOST

Offshore Targost

Recent Borings with Glacial Till Depth Information

Historic Features

Historic Features Identified from 1917 Sandborn Map

Potential Primary NAPL Sources (Sumps, Trenches, and other features with observed contamination)

Potential Secondary NAPL Source Areas

Trenching and other features of interest identified in April 1989 Map

Site Remediation Excavation Performed in 1992 through 1994

Buried Bulkhead (Same as 1917 Shoreline) and Sheet Pile Wall in Transfer Pit

Historic Underground Pipelines

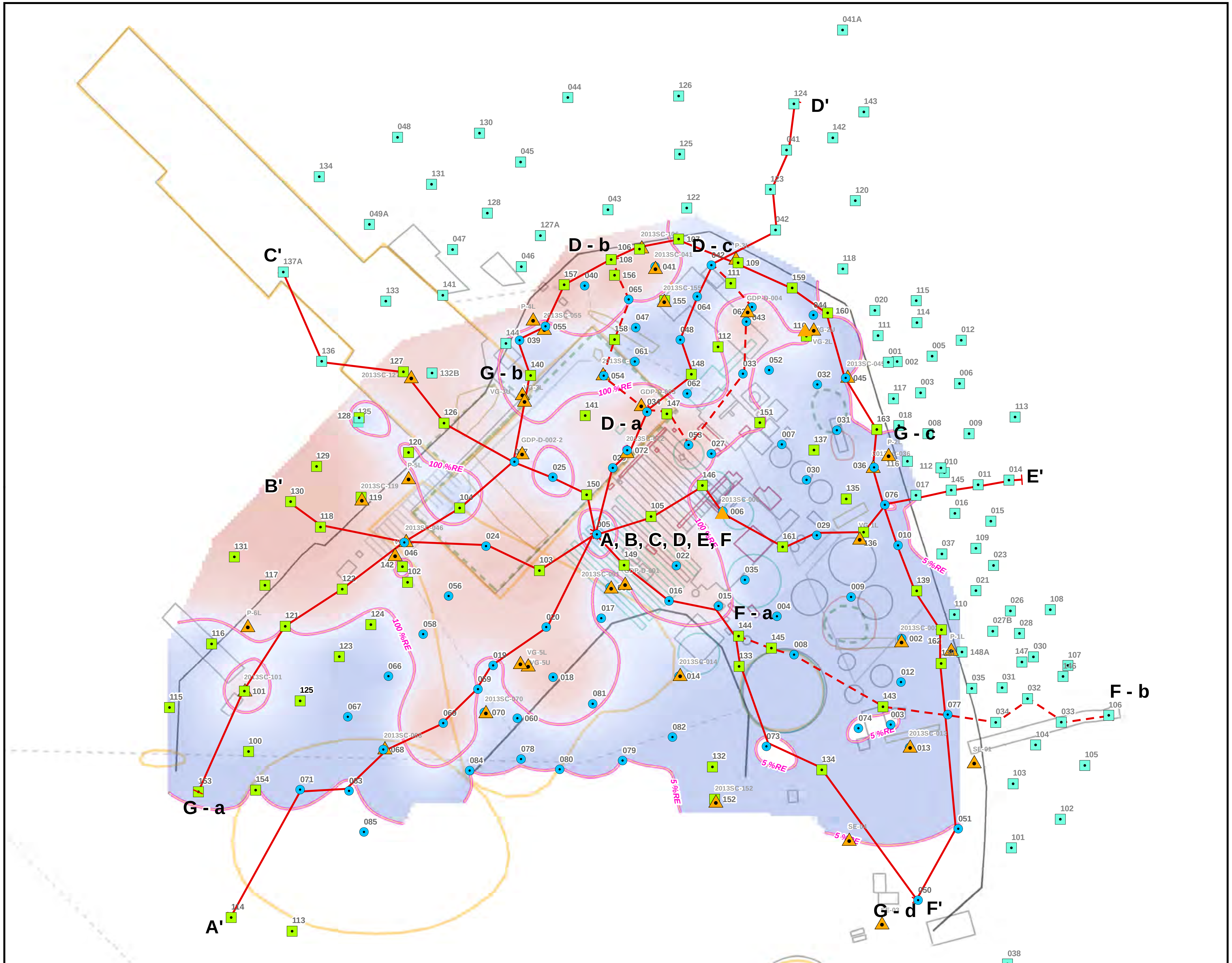
Sheet Pile Wall

N

0 50 100 200 Feet

Figure 4-9
Fence Diagram Locations
Phase 1 and 2 TarGOST Results
Maximum %RE Response - Shallow Zone
Wyckoff Upland Field Investigation
Wyckoff/Eagle Harbor Superfund Site

C:\USERS\GGEE\DOCUMENTS\GIS\WYCKOFF\MAPFILES\2013\FIELD INVESTIGATION SUMMARY MEMO\FIGURE4-9_FENCEDIAGRAMLOCATIONS_V2.MXD GGEE 6/25/2013 12:59:04 PM



LEGEND

Maximum %RE Contours of 5% and 100%

Maximum %RE Response - Near Aquitard

Low: -11%

Mid: 100%

High: 1,515%

Fence Diagram Location, dashed line indicates sub-location

TarGOST Location and Phase

Phase 1 TarGOST

Phase 2 TarGOST

Offshore Targost

Recent Borings with Glacial Till Depth Information

Historic Features

Historic Features Identified from 1917 Sandborn Map

Potential Primary NAPL Sources (Sumps, Trenches, and other features with observed contamination)

Potential Secondary NAPL Source Areas

Trenching and other features of interest identified in April 1989 Map

Site Remediation Excavation Performed in 1992 through 1994

Buried Bulkhead (Same as 1917 Shoreline) and Sheet Pile Wall in Transfer Pit

Historic Underground Pipelines

Sheet Pile Wall

N

0 50 100 200 Feet

Figure 4-10

Fence Diagram Locations

Phase 1 and 2 TarGOST Results

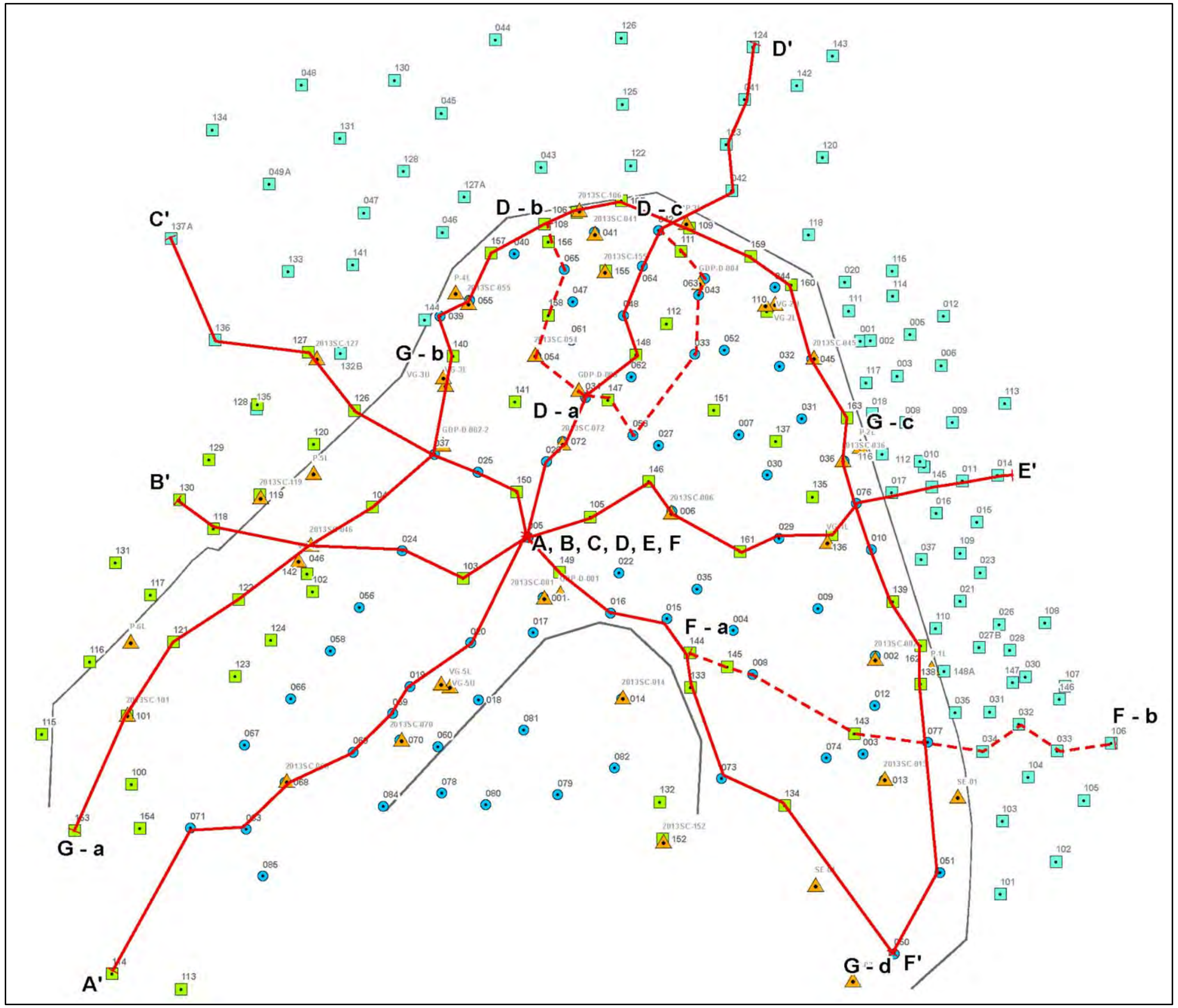
Maximum %RE Response - Near Aquitard

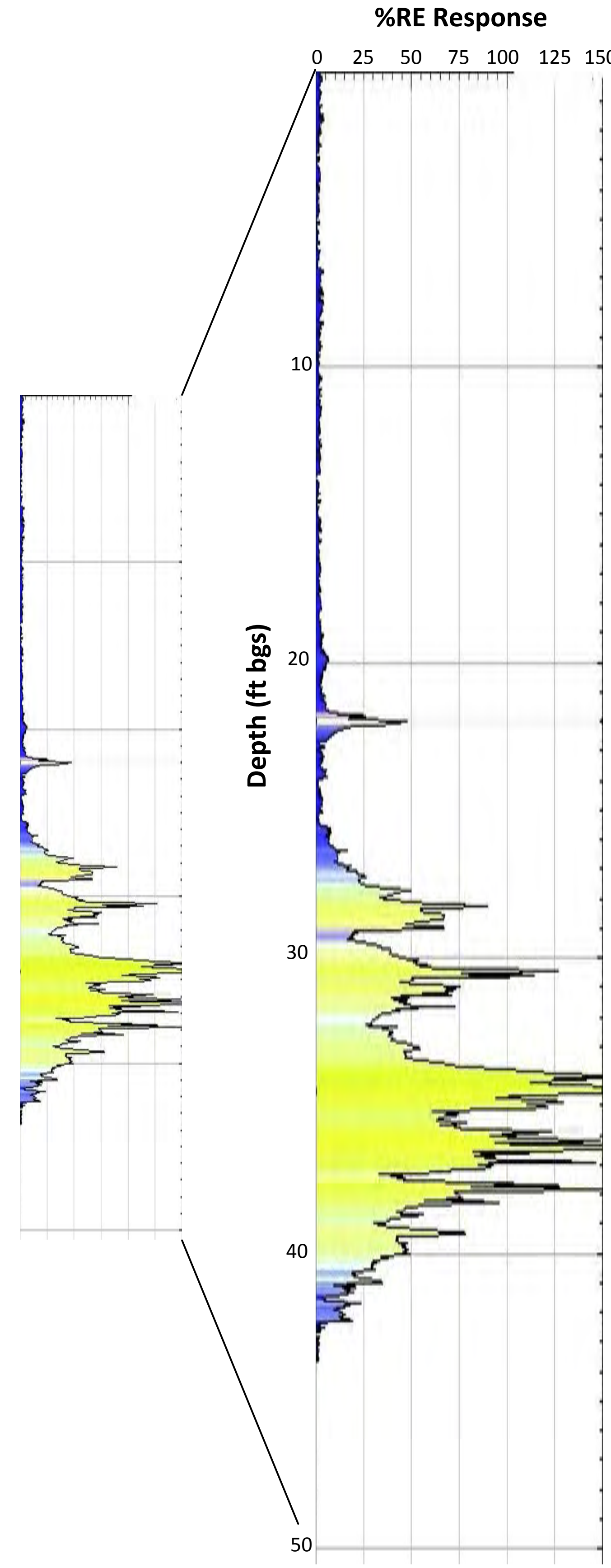
Wyckoff Upland Field Investigation

Wyckoff/Eagle Harbor Superfund Site

C:\USERS\GGEE\DOCUMENTS\GIS\WYCKOFF\MAPFILES\2013\FIELD INVESTIGATION SUMMARY MEMO\FIGURE4-4_FENCEDIAGRAMLOCATIONS_V2.MXD GGEE 6/25/2013 12:54:36 PM

Fence diagrams A through F radiate out from a TarGOST location central to the site (2013T-005). Fence diagram G (a through c) parallels the sheet pile wall on the upland portion of the site.
Dashed sub-fence diagrams are intended to follow potential flow paths of NAPL to the sheet pile wall.





LEGEND FOR FENCE DIAGRAM ELEMENTS

Ground surface extracted from GIS

Sheet Pile Wall

Glacial till depth indicated by recent boring <20 ft from fence

Depth to refusal of recent boring <20 ft from fence

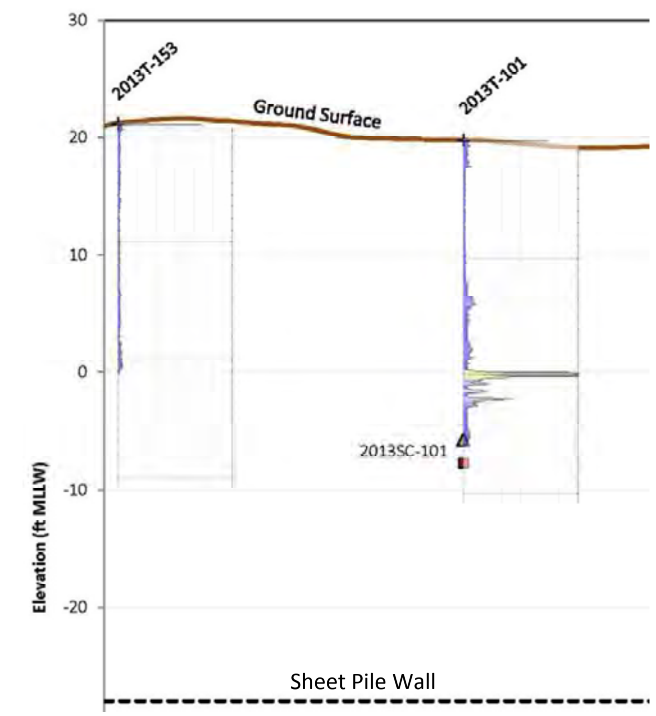


Figure 4-11
Legend for Fence Diagrams
Wyckoff Upland Field Investigation
Wyckoff/Eagle Harbor Superfund Site

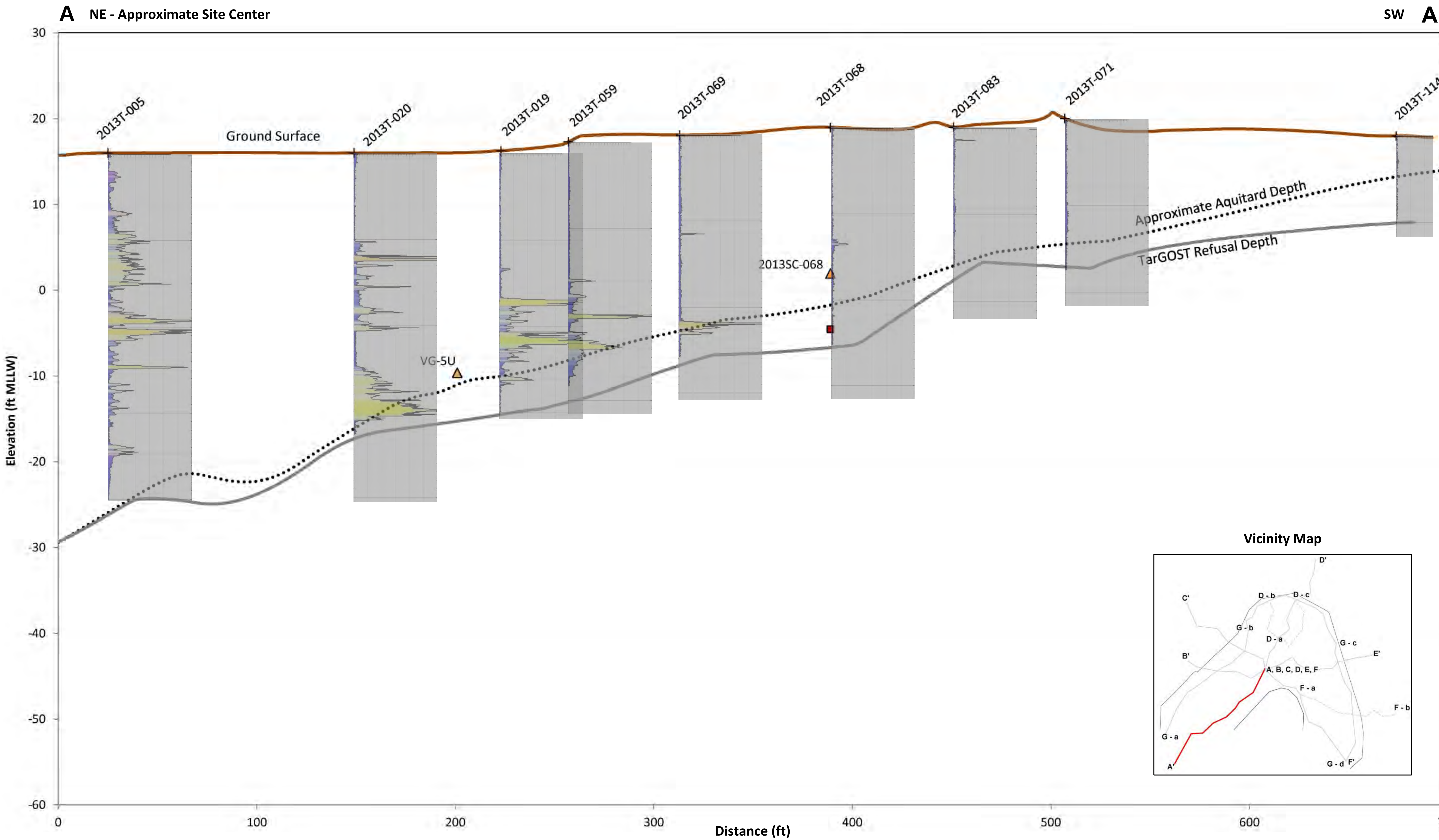


Figure 4-12

Fence Diagram A-A' with TarGOST %RE Response

Wyckoff Upland Field Investigation

Wyckoff/Eagle Harbor Superfund Site

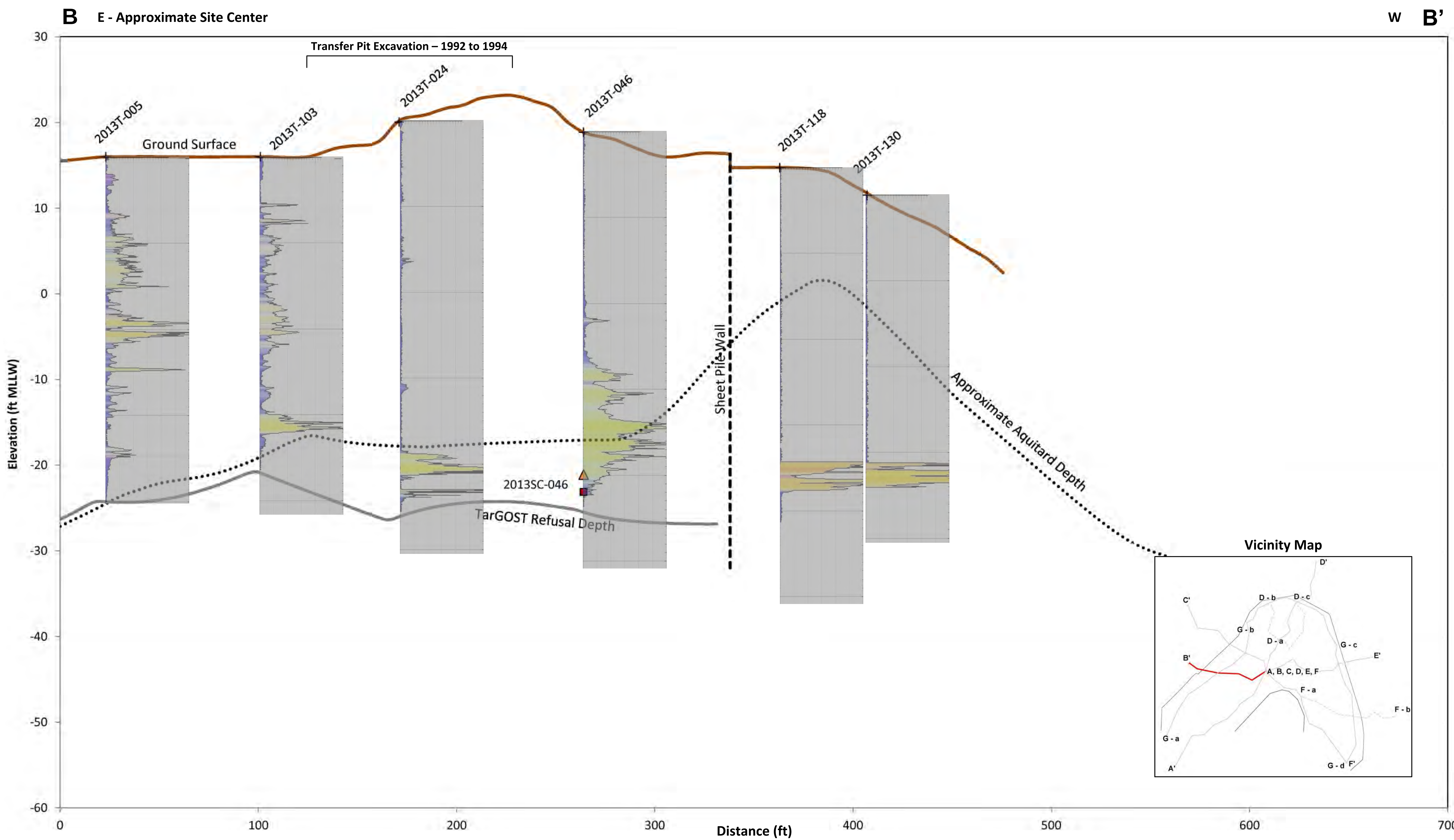


Figure 4-13

Fence Diagram B-B' with TarGOST %RE Response

Wyckoff Upland Field Investigation

Wyckoff/Eagle Harbor Superfund Site

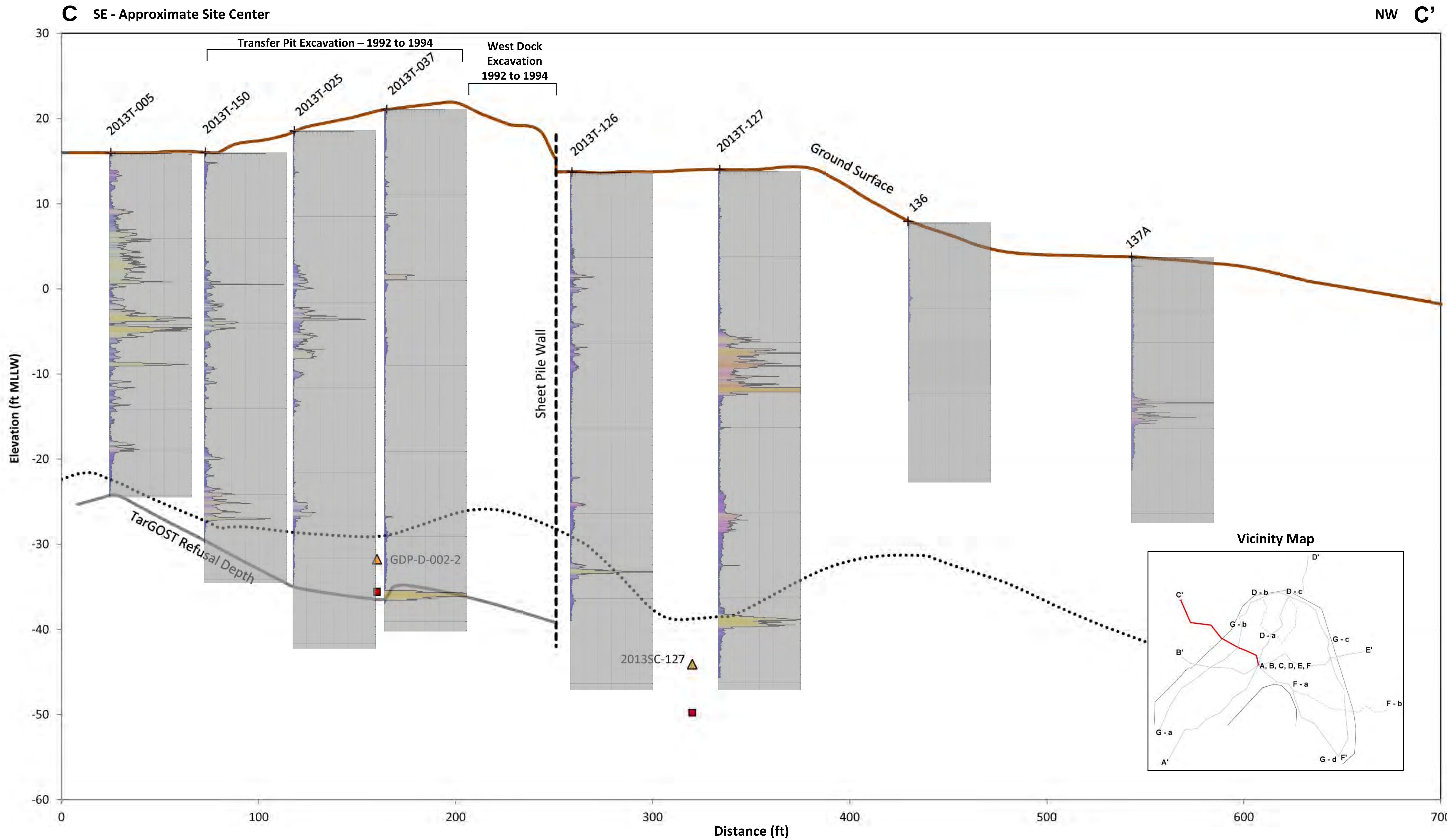


Figure 4-14

Fence Diagram C-C' with TarGOST %RE Response

Wyckoff Upland Field Investigation

Wyckoff/Eagle Harbor Superfund Site

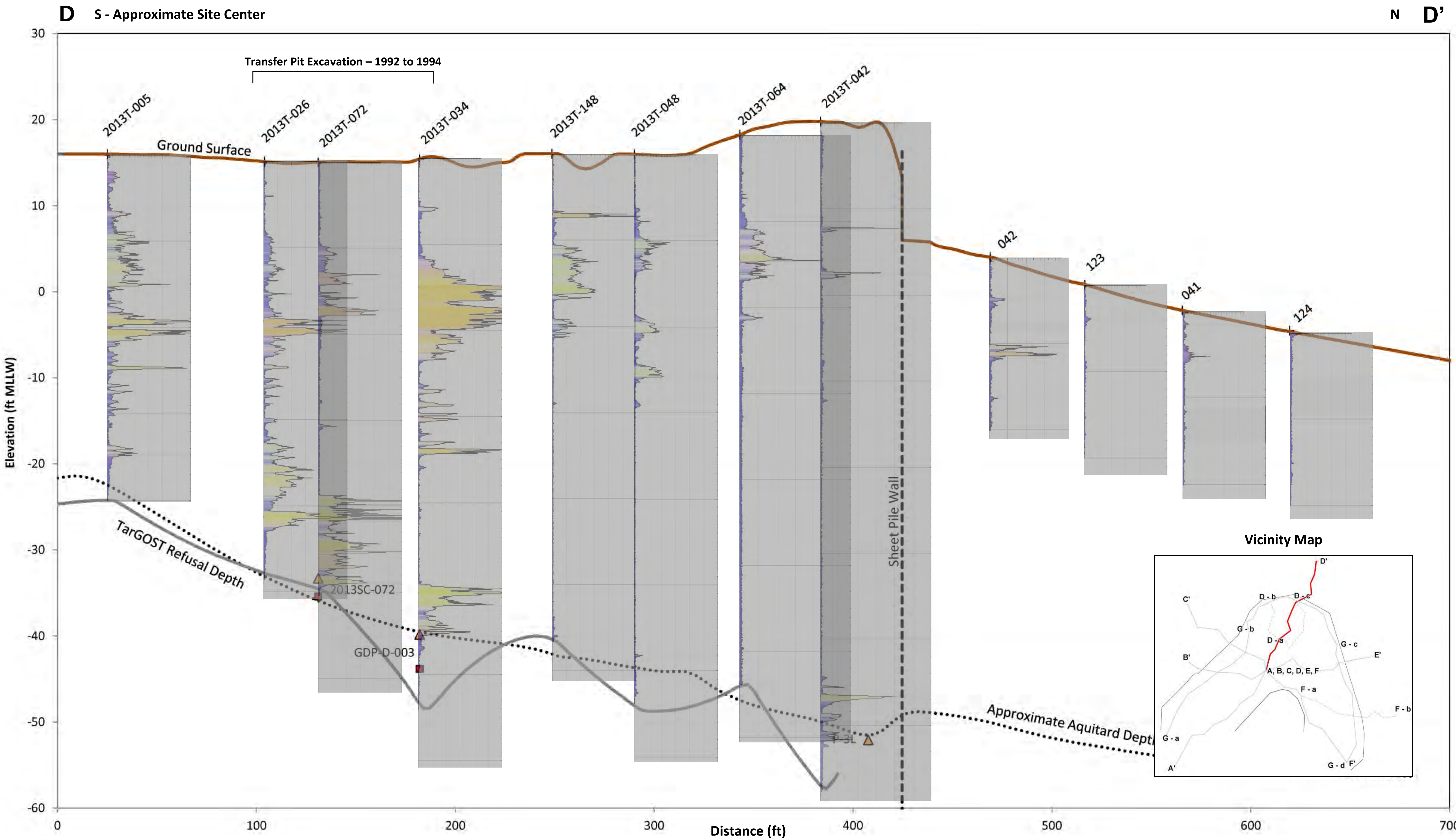


Figure 4-15

Fence Diagram D-D' with TarGOST %RE Response

Wyckoff Upland Field Investigation

Wyckoff/Eagle Harbor Superfund Site

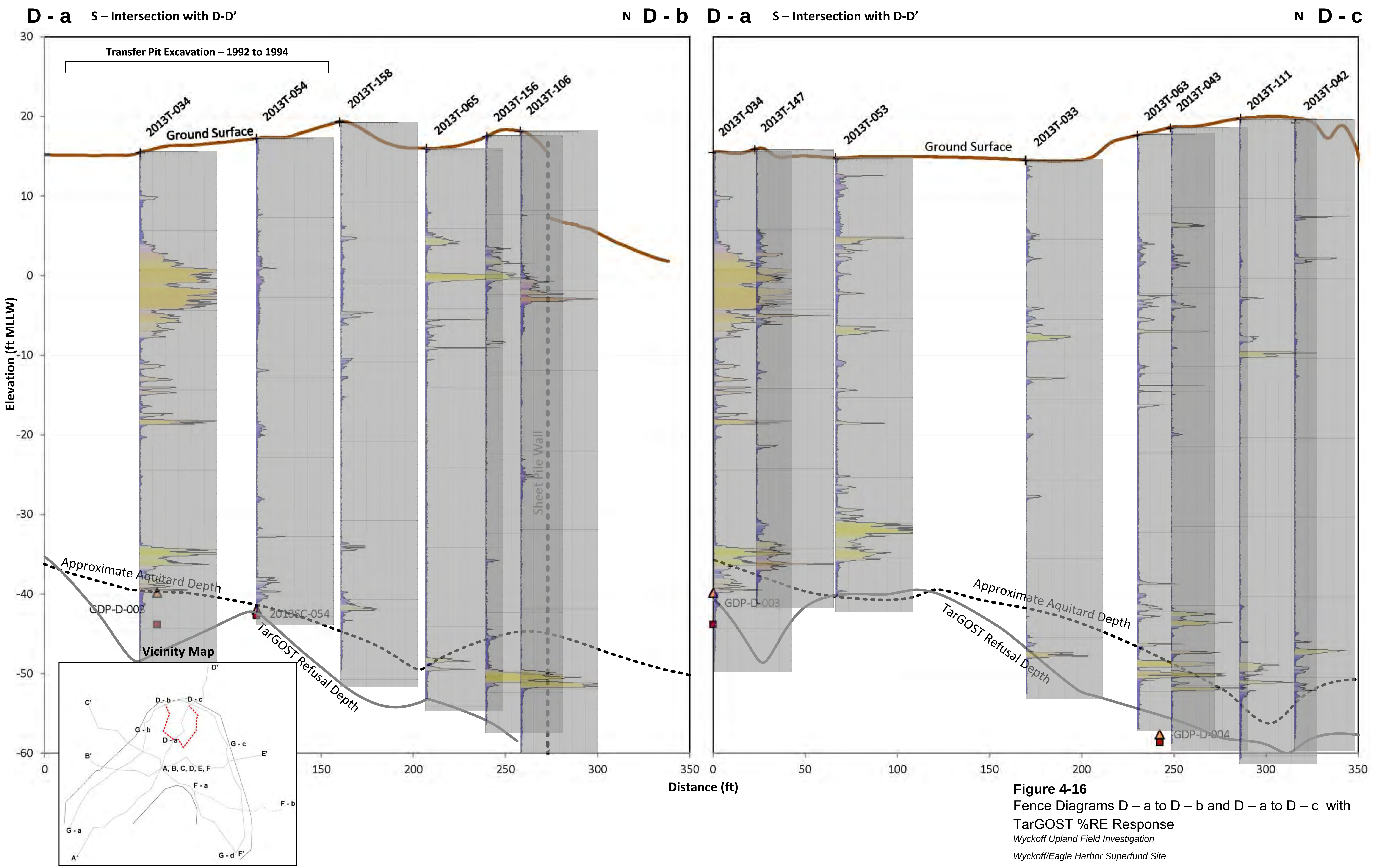


Figure 4-16
Fence Diagrams D – a to D – b and D – a to D – c with TarGOST %RE Response
Wyckoff Upland Field Investigation
Wyckoff/Eagle Harbor Superfund Site

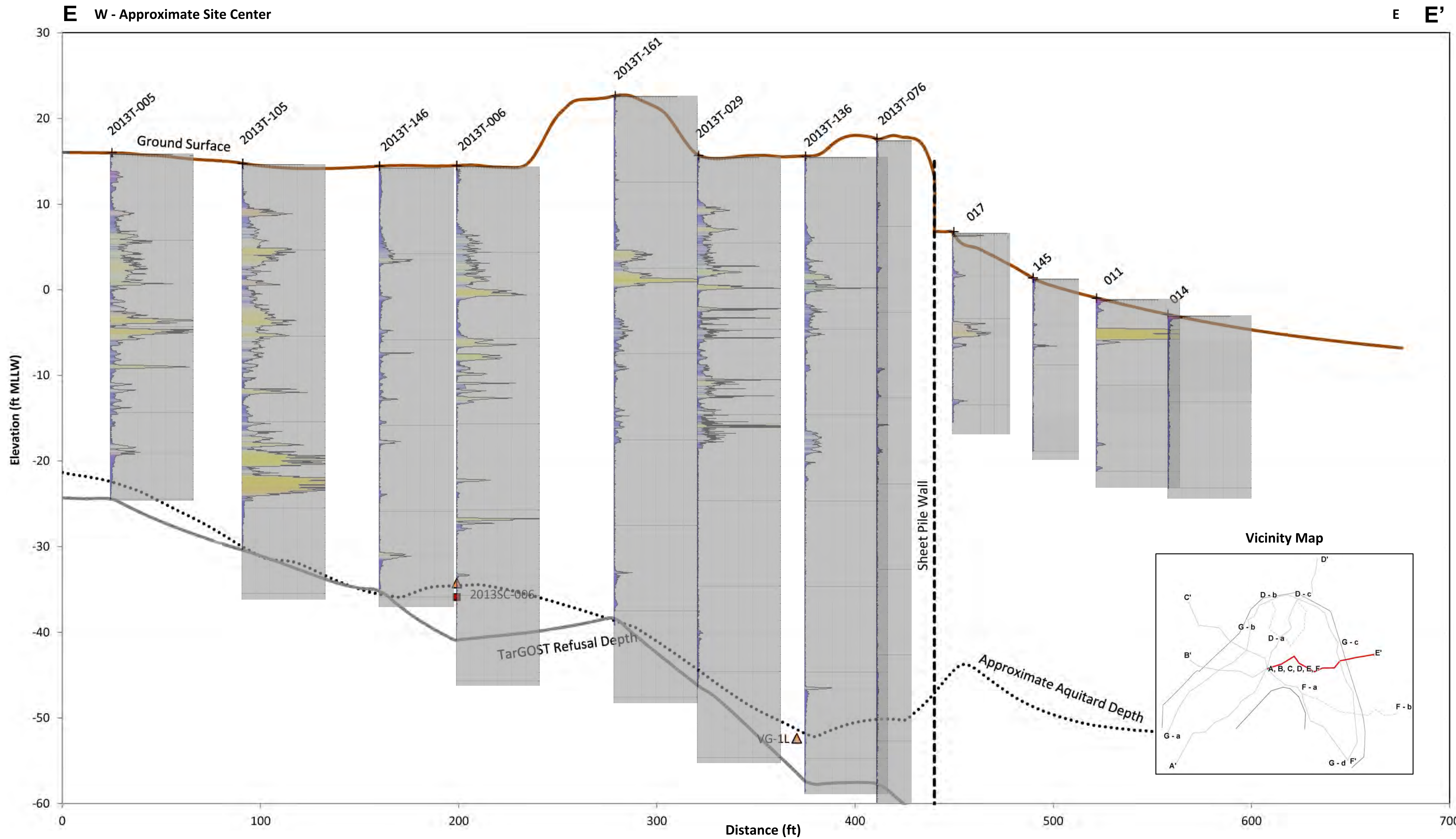


Figure 4-17

Fence Diagram E-E' with TarGOST %RE Response

Wyckoff Upland Field Investigation

Wyckoff/Eagle Harbor Superfund Site

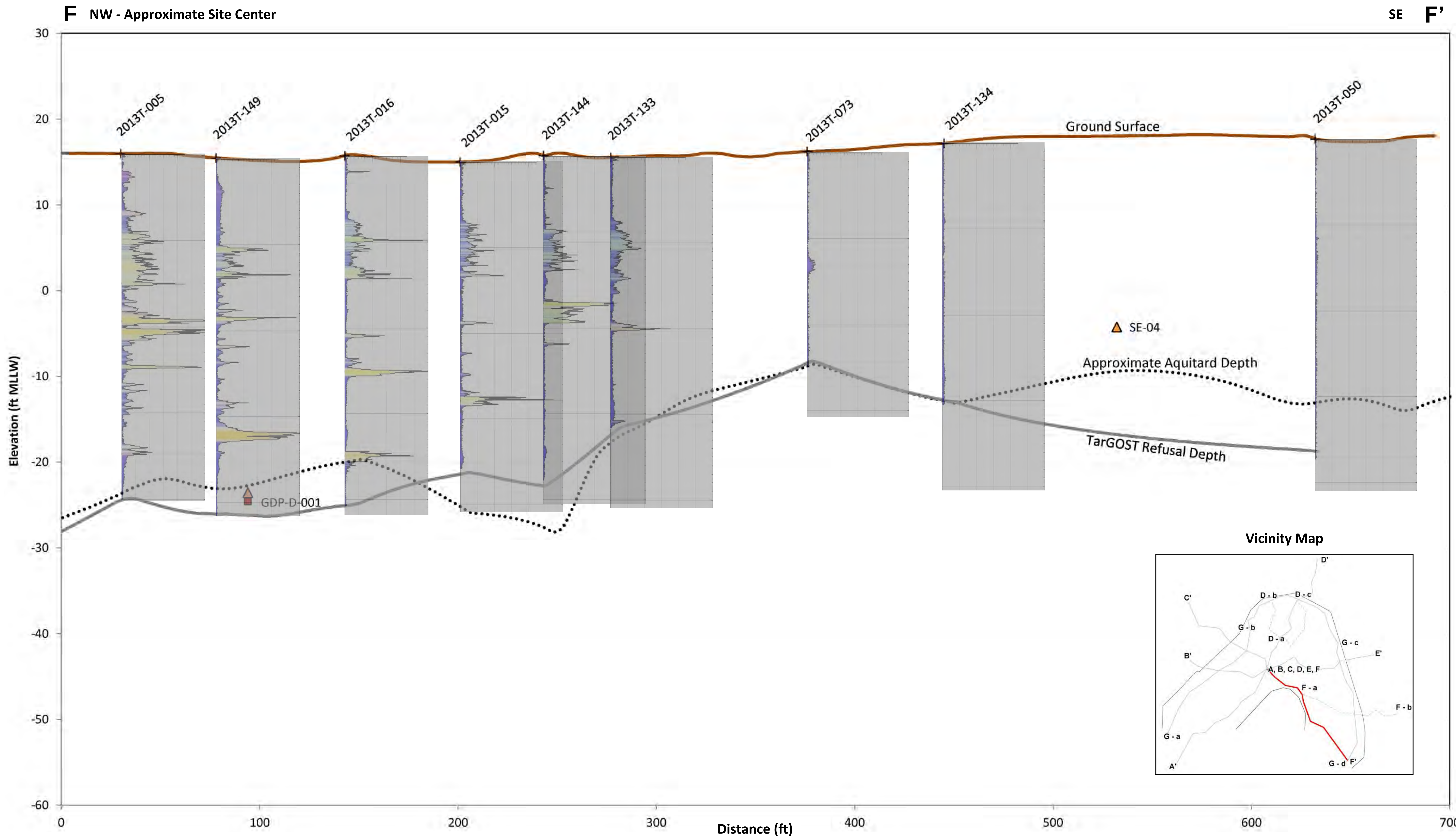


Figure 4-18

Fence Diagram F-F' with TarGOST %RE Response

Wyckoff Upland Field Investigation

Wyckoff/Eagle Harbor Superfund Site

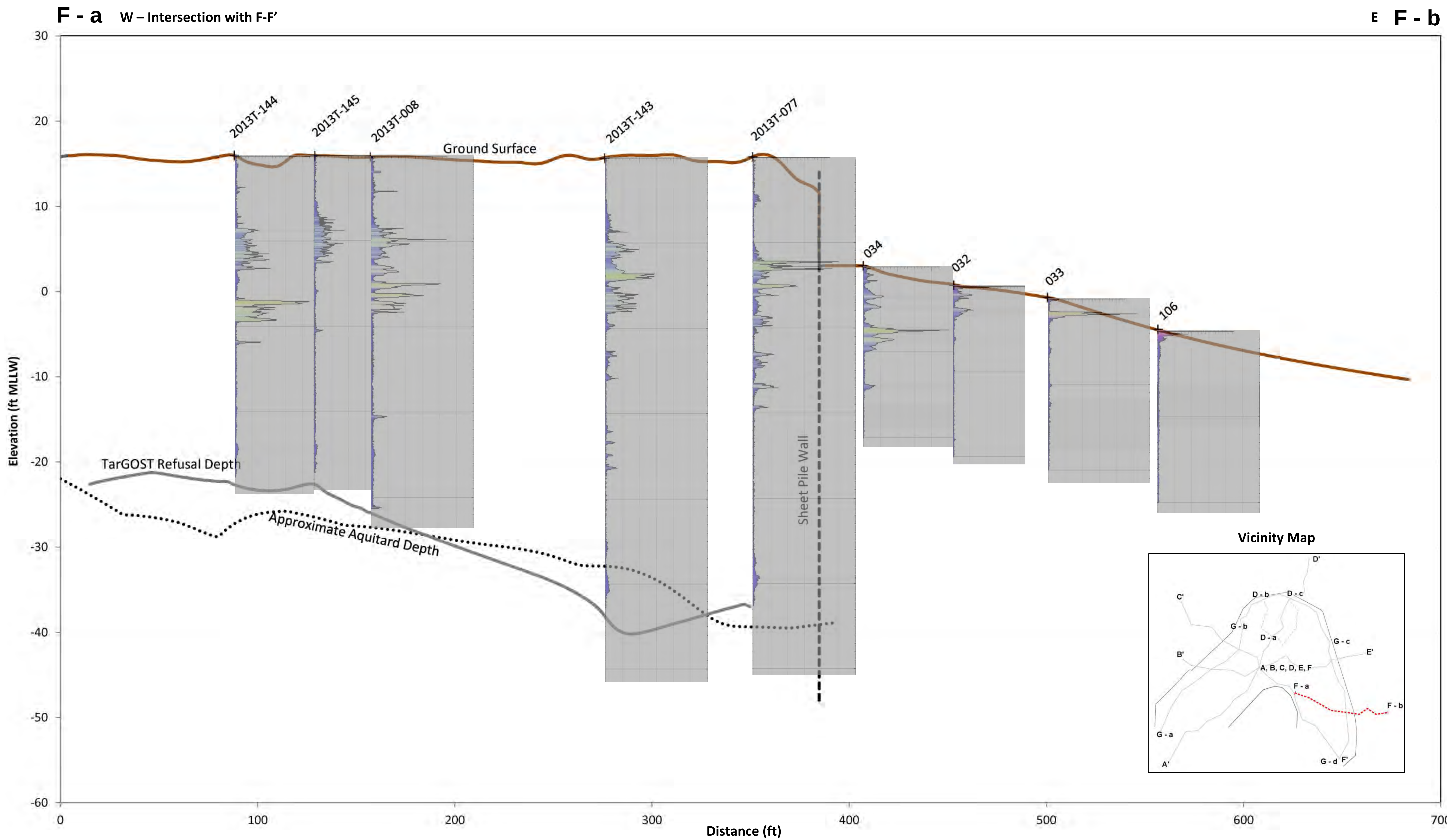
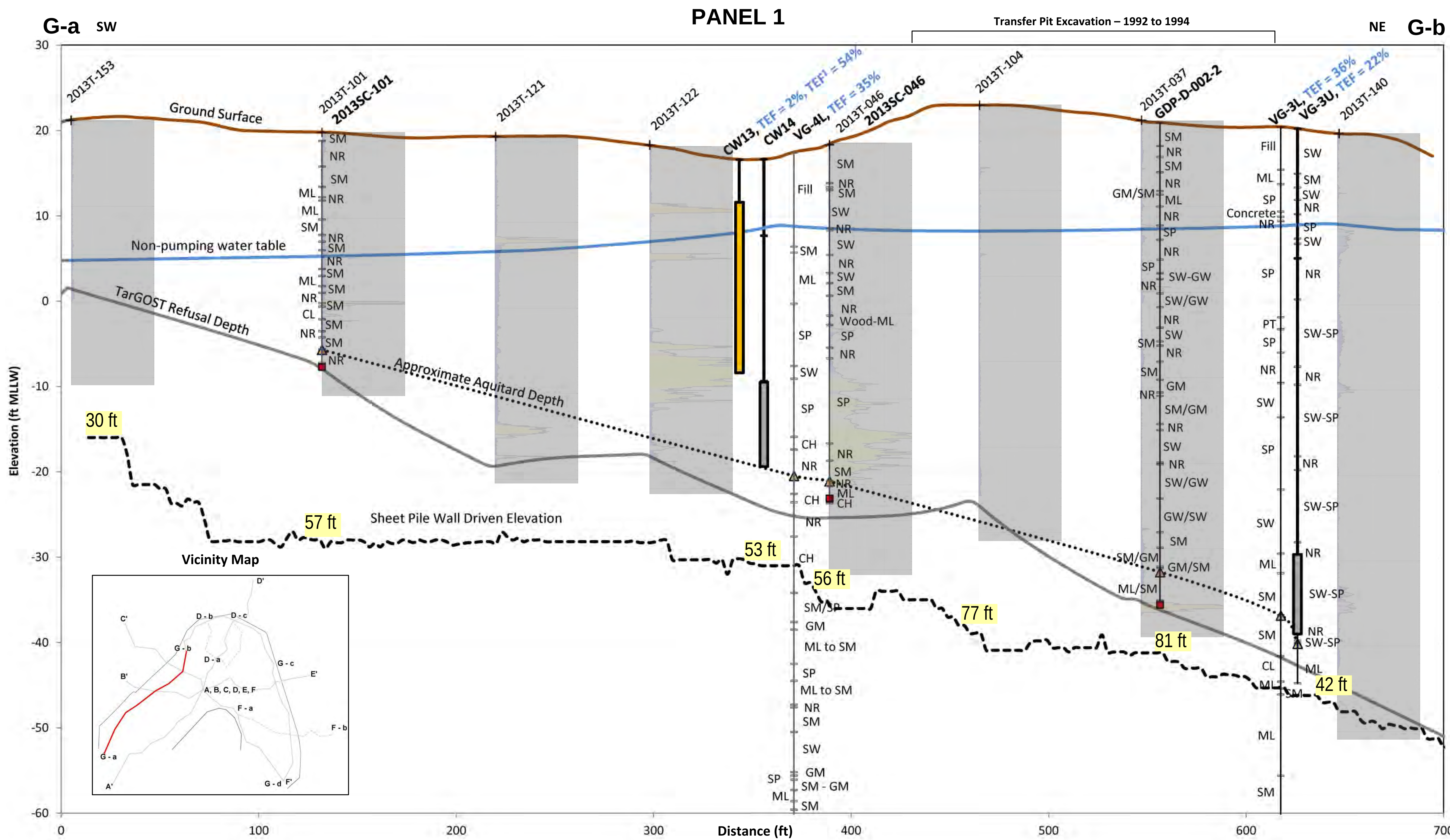


Figure 4-19

Fence Diagram F – a to F - b with TarGOST %RE Response

Wyckoff Upland Field Investigation

Wyckoff/Eagle Harbor Superfund Site



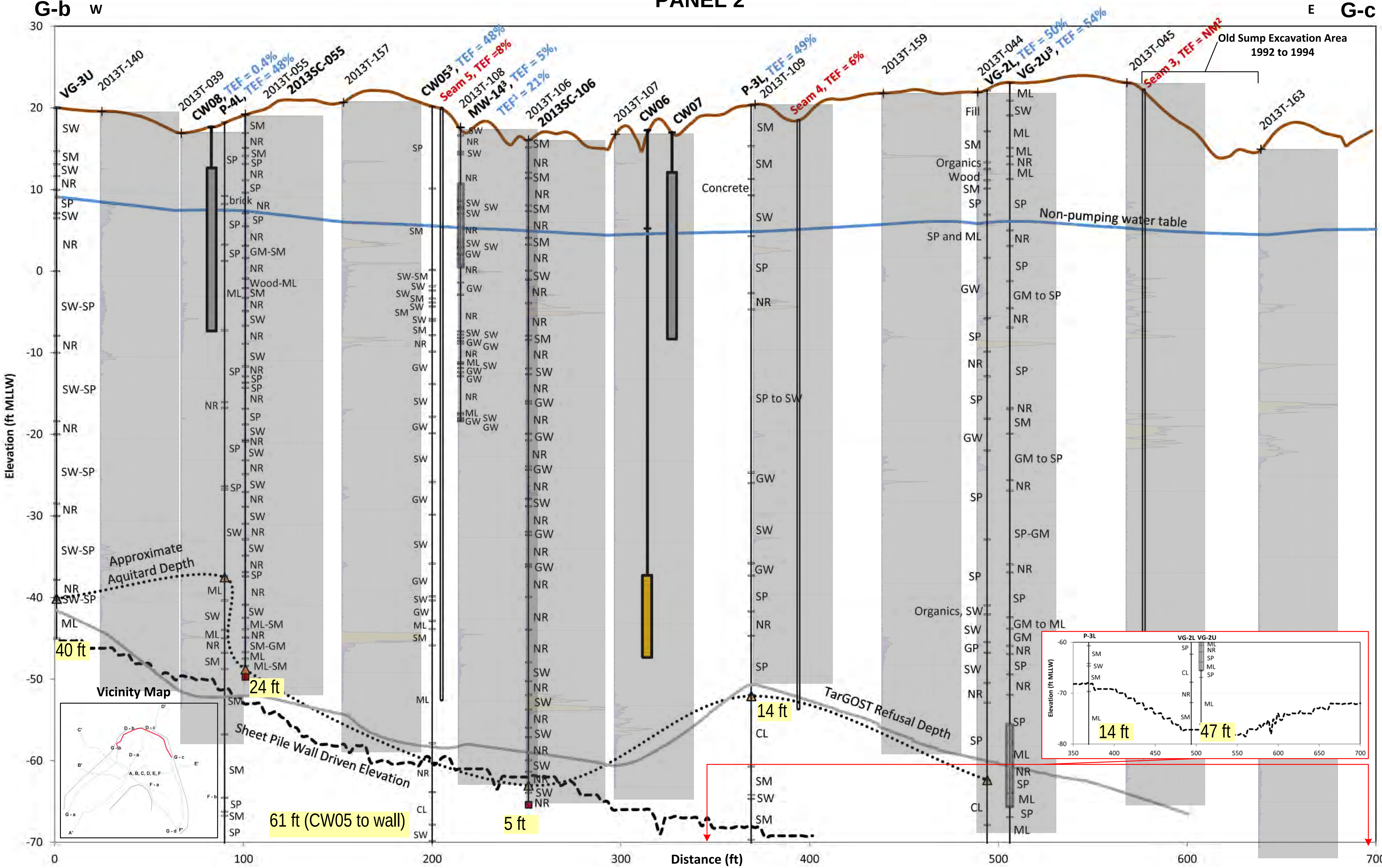
Groundwater Level Non-pumping Conditions (measured September 3, 2012)

Monitoring well screened interval
Orange color-code = NAPL was observed in well during water level monitoring (9/12); Gray color-code = NAPL was not observed in well during water level monitoring (9/12)

Notes:
TEF = Tidal Efficiency Factor
[1]Historical TEF measured prior to sheet pile wall installation.
[2]Tidal efficiency could not be measured from available data.
[3]Projection distance from feature to sheet pile wall.

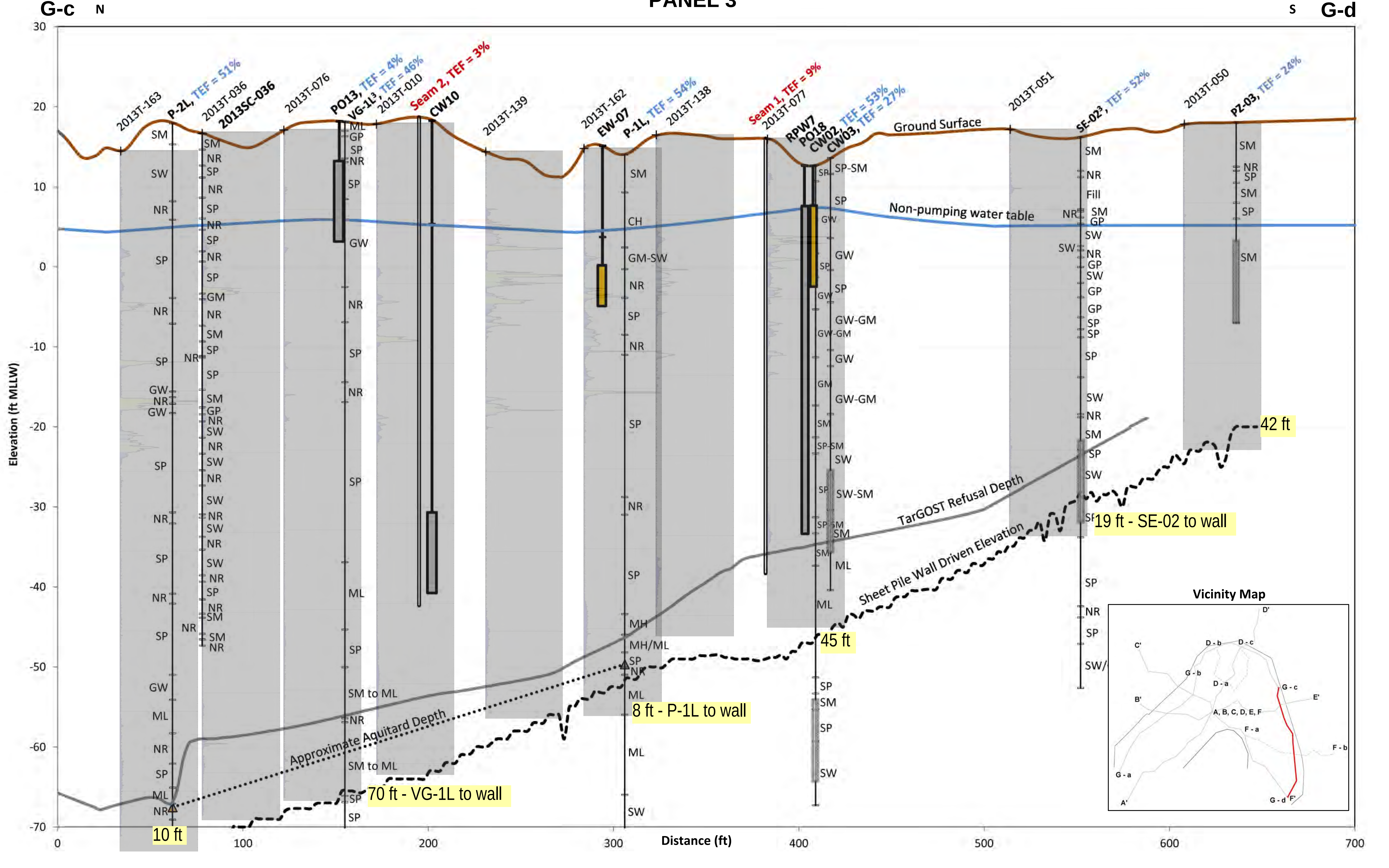
Figure 20 (Panels 1 – 3)
Fence Diagram G-a to G-b to G-c to G-d with TarGOST %RE Response
Wyckoff Sheet Pile Wall Investigation
Wyckoff/Eagle Harbor Superfund Site

PANEL 2

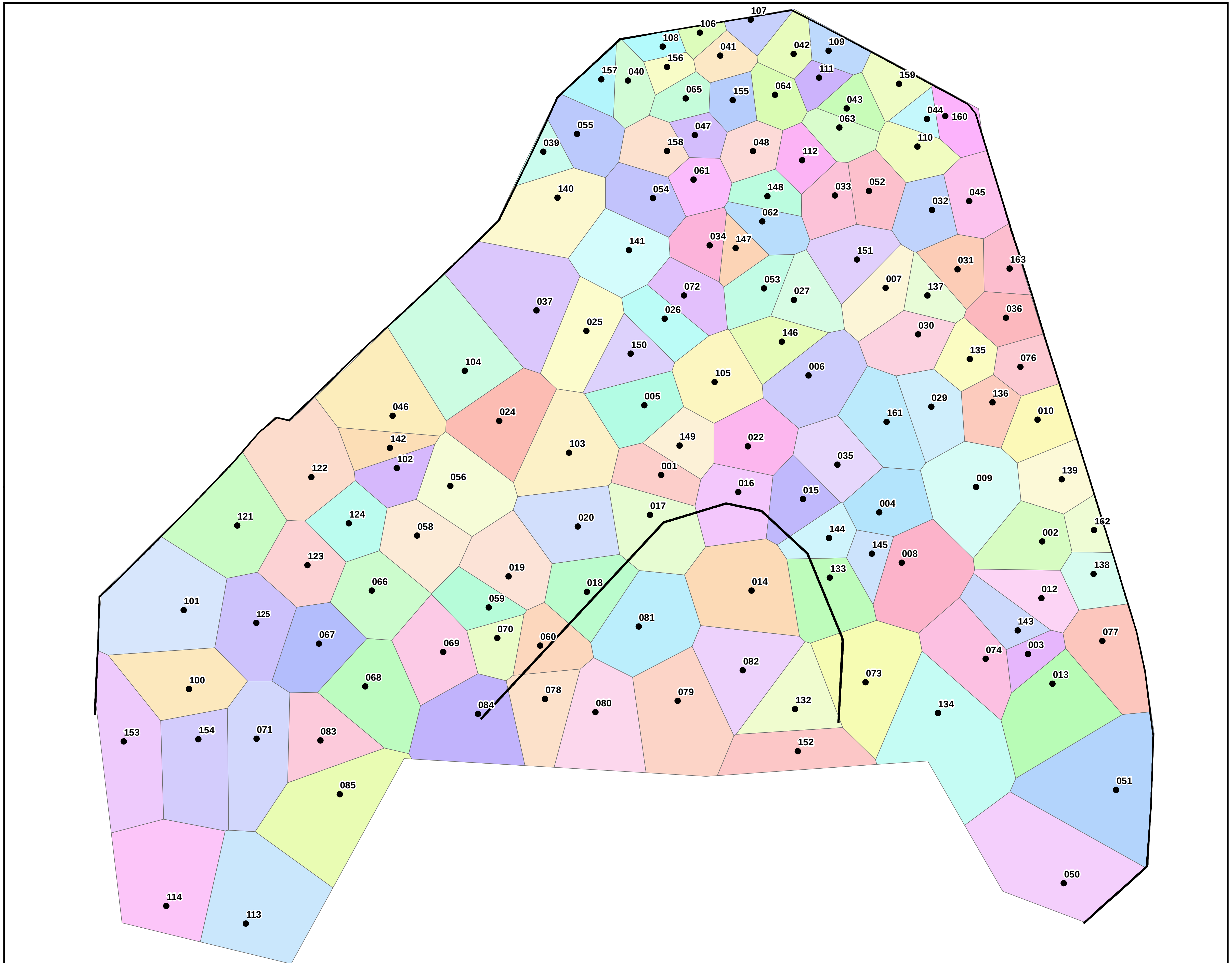


G-b
W
E
G-c
Elevation (ft MLLW)
Distance (ft)
30
20
10
0
-10
-20
-30
-40
-50
-60
-70
0
100
200
300
400
500
600
700
VG-3U
2013T-140
2013T-039
CW08, TEF = 0.4%
P-4L, TEF = 48%
2013T-055
2013SC-055
2013T-157
CW05³, TEF = 48%
Seam 5, TEF =8%
2013T-108
MW-14³, TEF = 5%,
TEF¹ = 21%
2013T-106
2013SC-106
2013T-107
CW06
CW07
P-3L, TEF = 49%
2013T-109
Seam 4, TEF = 6%
2013T-159
2013T-044
VG-2L, TEF = 50%
VG-2U³, TEF = 54%
2013T-045
Seam 3, TEF = NM²
Old Sump Excavation Area
1992 to 1994
2013T-163
Non-pumping water table
Concrete
brick
Fill
Organics
Wood
SP and ML
Organics, SW
Approximate
Aquitard Depth
Sheet Pile Wall Driven Elevation
TarGOST Refusal Depth
40 ft
24 ft
14 ft
5 ft
61 ft (CW05 to wall)
47 ft
Vicinity Map
P-3L
VG-2L VG-2U

PANEL 3



G-c
N
S
G-d
Elevation (ft MLLW)
Distance (ft)
2013T-163
P-2L, TEF = 51%
2013T-036
2013SC-036
2013T-076
PO13, TEF = 4%
VG-1L3, TEF = 46%
2013T-010
Seam 2, TEF = 3%
CW10
2013T-139
2013T-162
EW-07
P-1L, TEF = 54%
2013T-138
Seam 1, TEF = 9%
2013T-077
RPW7
PO18
CW02, TEF = 53%
CW03, TEF = 27%
2013T-051
SE-023, TEF = 52%
2013T-050
PZ-03, TEF = 24%
Ground Surface
Non-pumping water table
TarGOST Refusal Depth
Sheet Pile Wall Driven Elevation
Approximate Aquitard Depth
10 ft
70 ft - VG-1L to wall
8 ft - P-1L to wall
45 ft
19 ft - SE-02 to wall
42 ft
Vicinity Map



LEGEND

- TarGOST Phase 1 and 2
- Theissen Polygon
- Sheet Pile Wall

Note
Labels for TarGOST Phase 1 and 2 locations shown without 2013T-* prefix.

N

0 50 100 200 Feet

Figure 4-21
Thiessen Polygons for Volume Estimate
Upland Dataset
Wyckoff Upland Field Investigation
Wyckoff/Eagle Harbor Superfund Site

C:\USERS\GGEE\DOCUMENTS\GIS\WYCKOFF\MAPFILES\2013\FIELD INVESTIGATION SUMMARY MEMO\FIGURE4-21_THEISSENPOLYS.MXD GGEE 6/25/2013 1:04:55 PM

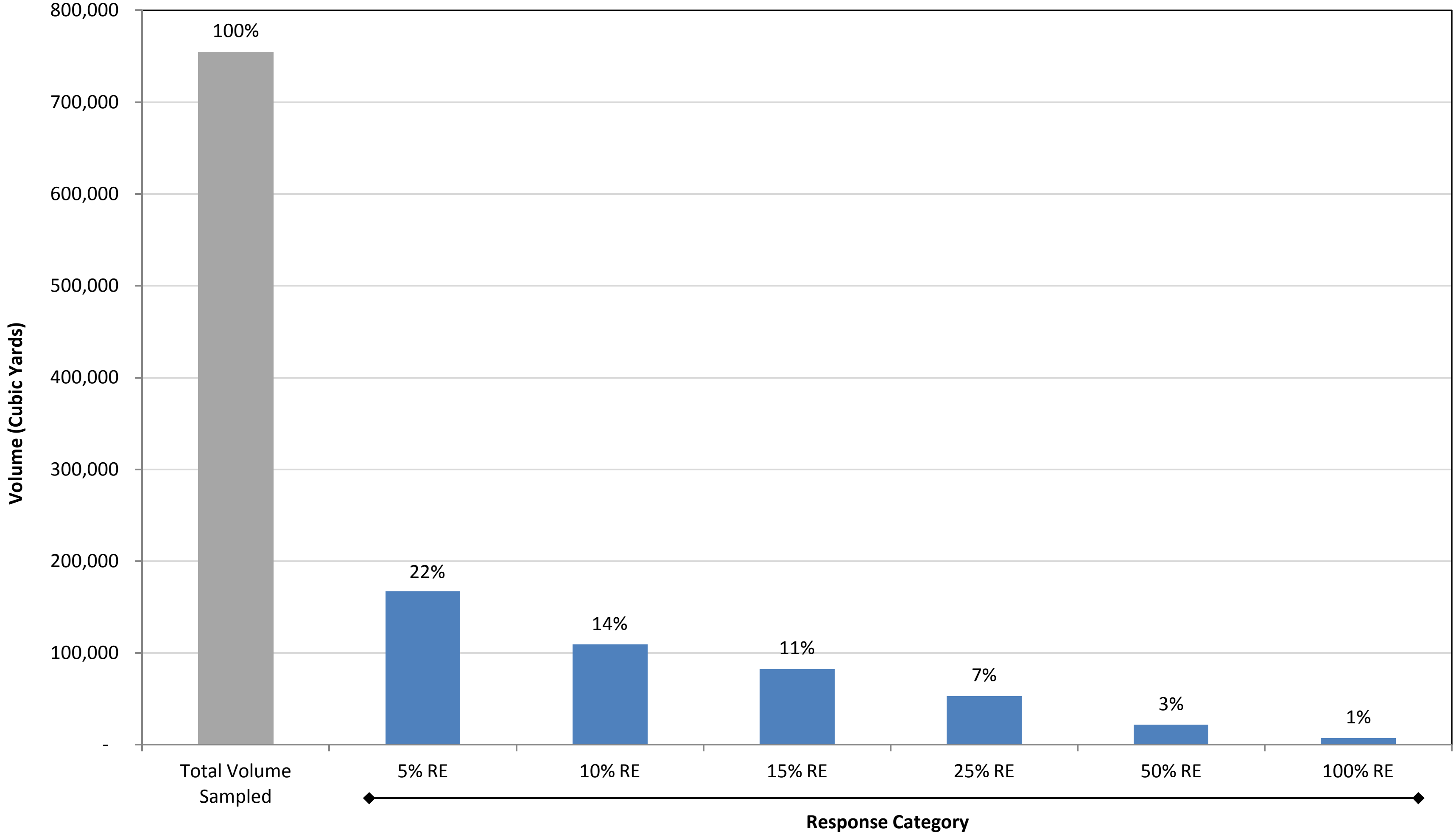
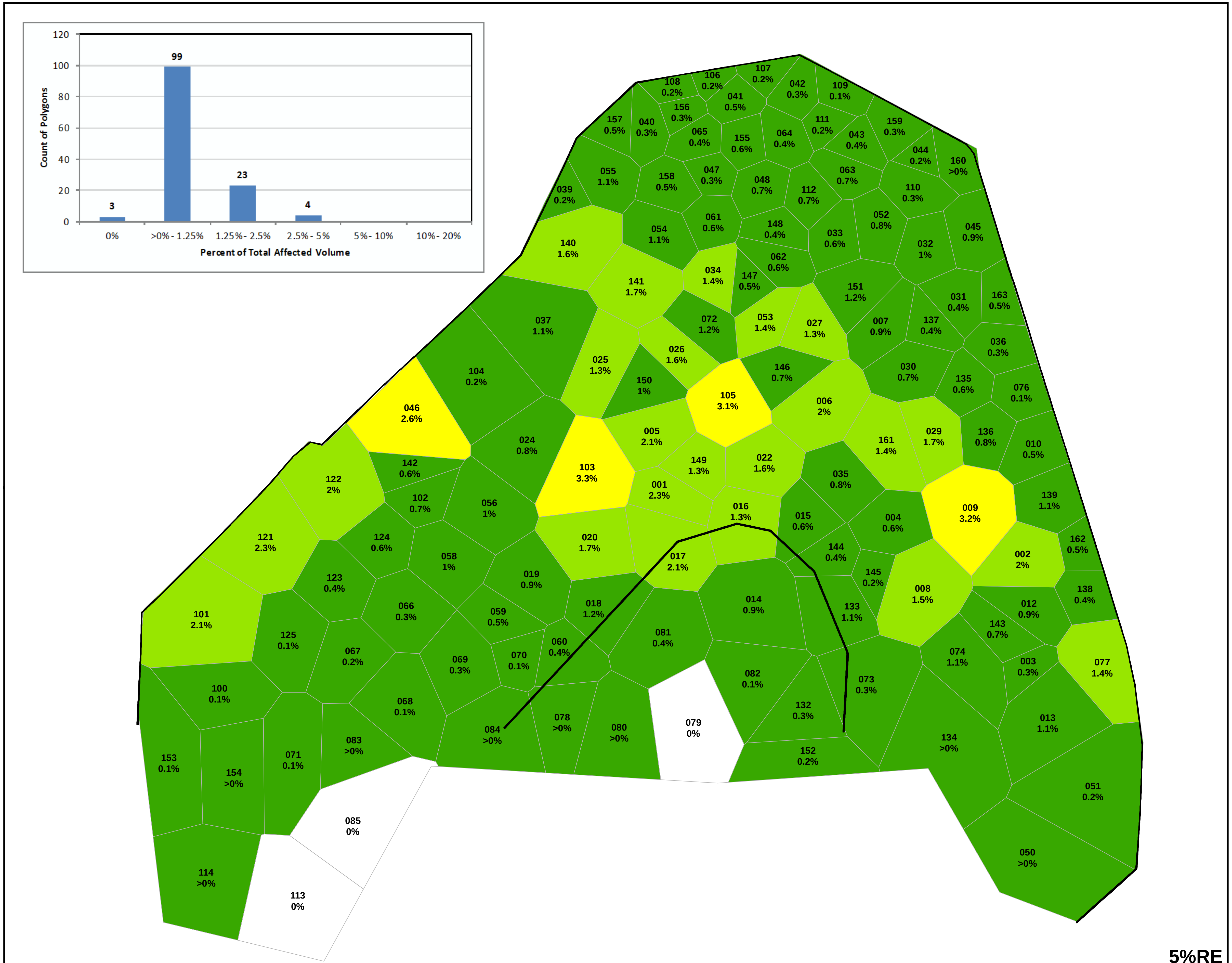


Figure 4-22

Total Sampled Volume Compared with the Total NAPL-Impacted Volume by Response Category

Wyckoff Upland Field Investigation

Wyckoff/Eagle Harbor Superfund Site



LEGEND

Percent of Total Affected Volume

(Area of polygons within each class)

	0%	(0.6 acres)
	>0% - 1.25%	(7.7 acres)
	1.25% - 2.5%	(2.3 acres)
	2.5% - 5%	(0.5 acres)
	5% - 10%	(0 acres)
	10% - 20%	(0 acres)
	Sheet Pile Wall	

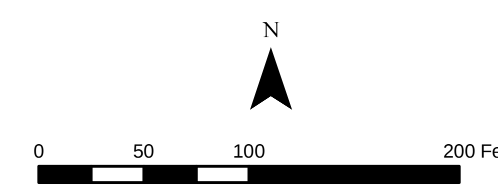
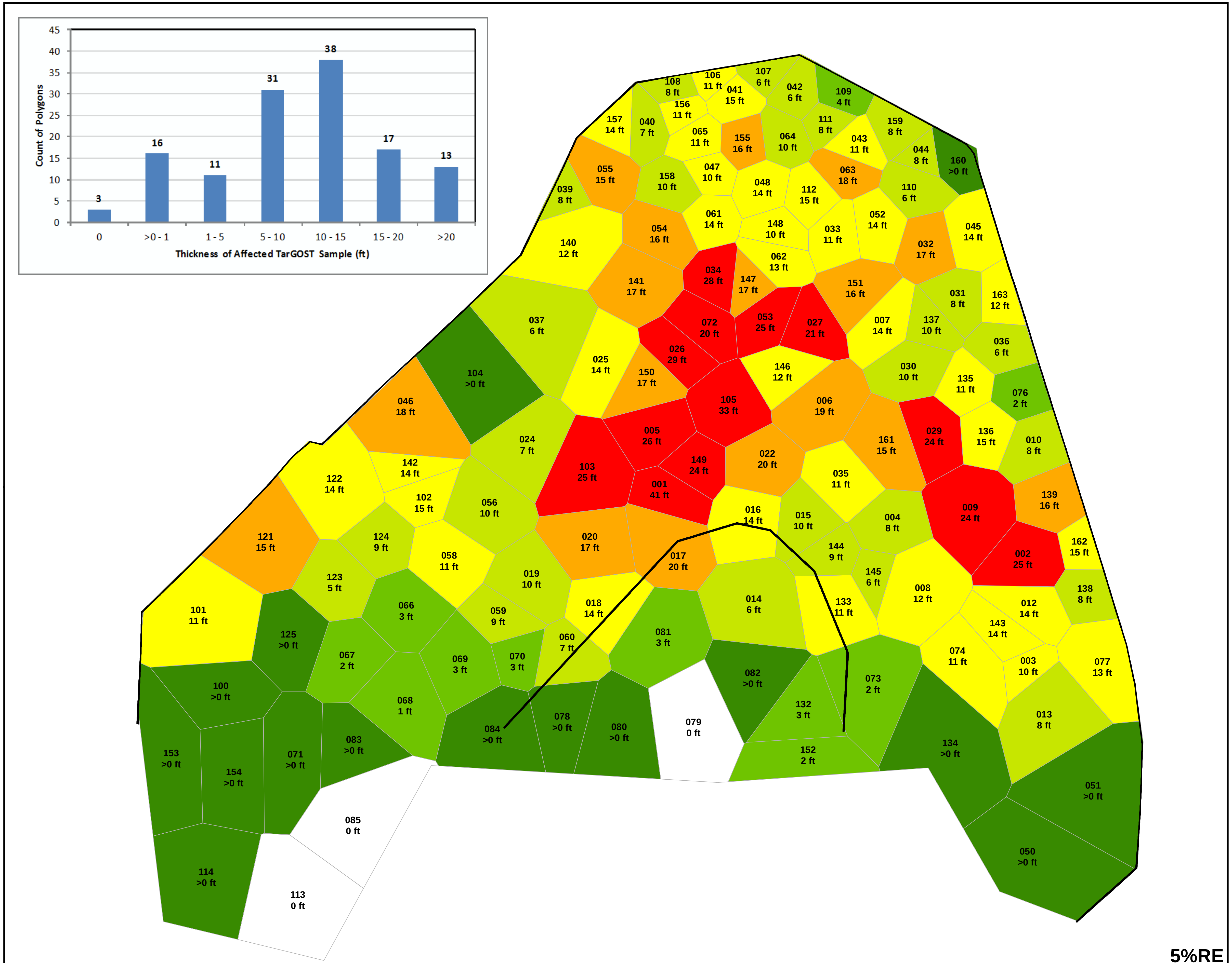


Figure 4-23
Thiessen Polygon Volume Estimate
5%RE
Upland Dataset

Wyckoff Upland Field Investigation
Wyckoff/Eagle Harbor Superfund Site



LEGEND

Thickness of Affected TarGOST Sample (ft)

(Area of polygons within each class)

- 0 (0.6 acres)
- >0 - 1 (2.3 acres)
- 1 - 5 (1.0 acres)
- 5 - 10 (2.1 acres)
- 10 - 15 (2.6 acres)
- 15 - 20 (1.4 acres)
- >20 (1.0 acres)
- Sheet Pile Wall

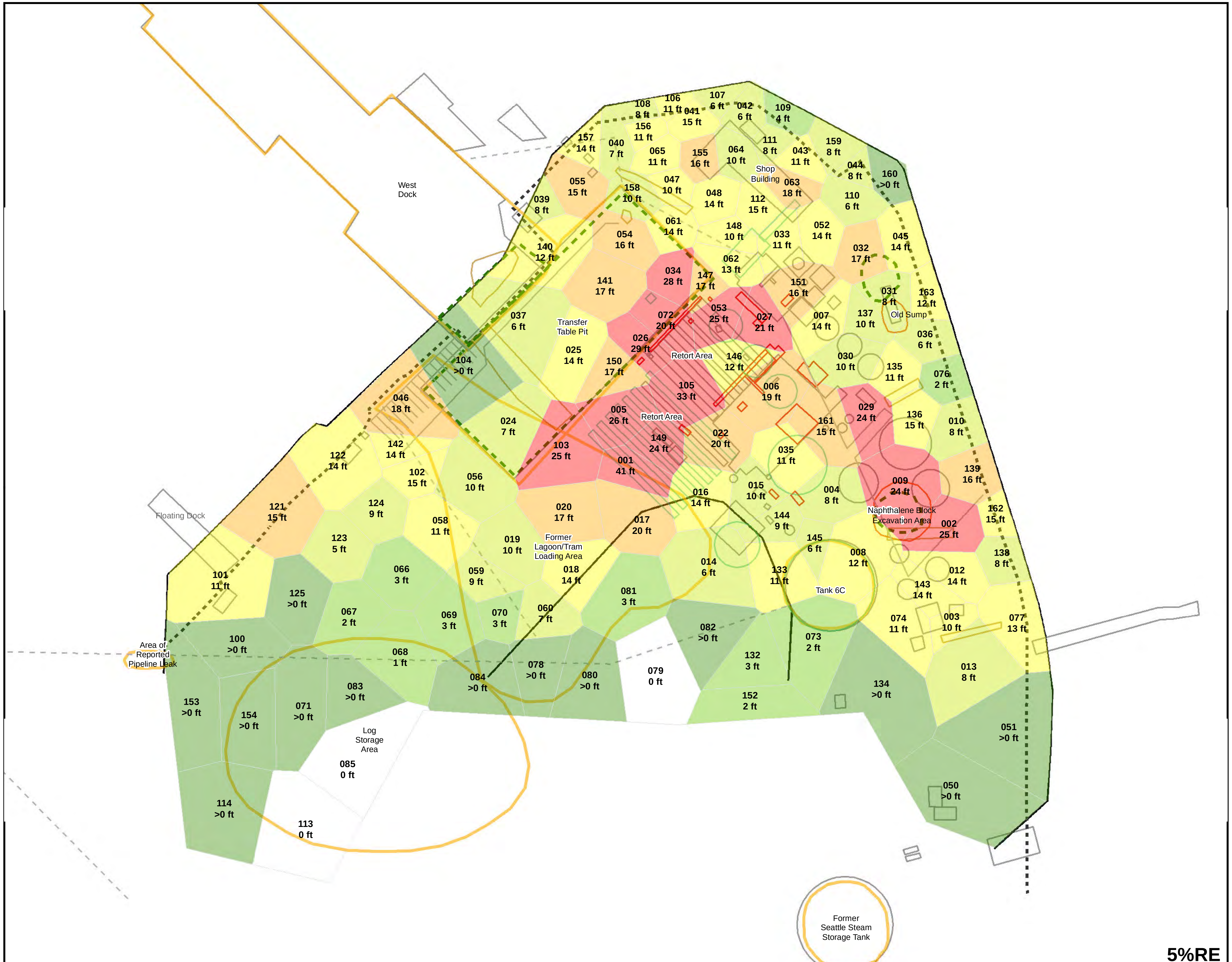
N

0 50 100 200 Feet

Figure 4-24
Thickness of Affected TarGOST Samples
5%RE
Upland Dataset

Wyckoff Upland Field Investigation
Wyckoff/Eagle Harbor Superfund Site

C:\USERS\GGEE\DOCUMENTS\GIS\WYCKOFF\MAPFILES\2013\FIELD INVESTIGATION SUMMARY MEMO\FIGURE4-24_THEISSENTHICK5RE.MXD GGEE 9/6/2013 8:54:02 AM



LEGEND

Thickness of Affected TarGOST Sample IW

(Area of polygons within each class)

- 0 (0.6 acres)
- >0 - 1 (2.3 acres)
- 1 - 5 (1.0 acres)
- 5 - 10 (2.1 acres)
- 10 - 15 (2.6 acres)
- 15 - 20 (1.4 acres)
- >20 (1.0 acres)
- Historic Features
- Historic Features Identified from 1917 Sandborn Map
- Site Remediation Excavation Performed in 1992 through 1994
- Potential Primary NAPL Sources (Sumps, Trenches, and other features with observed contamination)
- Potential Secondary NAPL Source Areas
- Trenching and other features of interest identified in April 1989 Map
- Bulk Head Prior to Current Sheet Pile Wall
- Current Sheet Pile Wall

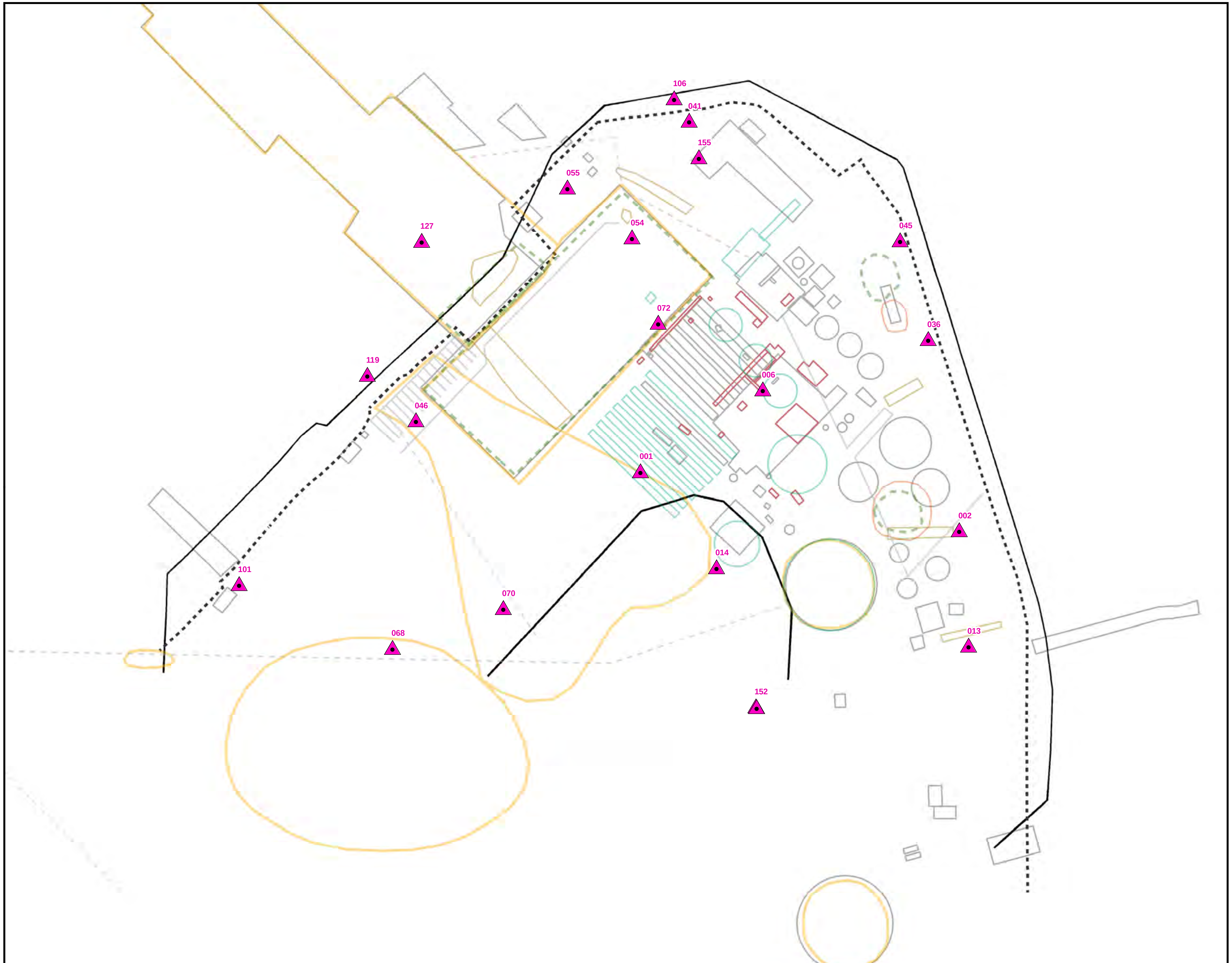
Sources:
Bulk Head Prior to Current Sheet Pile Wall digitized from current sheet pile wall design drawings (USACE, 2000)
Some sumps and trenches were digitized from "Figure 1 Site Location" (Environment and Ecology, 1995)
Sumps and Trenches were digitized from "Figure B Area 1 Trenches and Sumps"; "Figure C Area 2 Drums, Sumps, 7 Tanks"; "Figure D Area 3 Containers, Drums, Sumps, Tanks & Trenches" (Environment and Ecology, 1995)
Secondary NAPL Source Locations digitized from "Figure 2-1 Wycoff Site Vicinity Map" (CH2M HILL, 1993)
Trenching observations digitized from 1989 hand markup.
Prioritizing of source areas conducted 2012.
Prior remediation excavation areas from 1992 through 1994 digitized from Ecology and Environment, Inc., 1995.

N

0 60 120 240 Feet

Figure 4-25
Thickness of Affected TarGOST Samples 5%RE with Source Areas Shown Upland Dataset
Wyckoff Upland Field Investigation
Wyckoff/Eagle Harbor Superfund Site

C:\USERS\GGEE\DOCUMENTS\GIS\WYCKOFF\MAPFILES\2013\FIELD INVESTIGATION SUMMARY MEMO\FIGURE4-25_5RESOURCEAREAOVERLAY.MXD GGEE 9/9/2013 2:01:01 PM



LEGEND

&RQILUPDWLRQ%RULQJ

Historic Features

Historic Features Identified from 1917 Sandborn Map

Site Remediation Excavation Performed in 1992 through 1994

Potential Primary NAPL Sources (Sumps, Trenches, and other features with observed contamination)

Potential Secondary NAPL Source Areas

Trenching and other features of interest identified in April 1989 Map

Bulk Head Prior to Current Sheet Pile Wall

Current Sheet Pile Wall

Sources:
Bulk Head Prior to Current Sheet Pile Wall digitized from current sheet pile wall design drawings (USACE, 2000)
Some sumps and trenches were digitized from "Figure 1 Site Location" (Environment and Ecology, 1995)
Sumps and Trenches were digitized from "Figure B Area 1 Trenches and Sumps"; "Figure C Area 2 Drums, Sumps, 7 Tanks"; "Figure D Area 3 Containers, Drums, Sumps, Tanks & Trenches" (Environment and Ecology, 1995)
Secondary NAPL Source Locations digitized from "Figure 2-1 Wycoff Site Vicinity Map" (CH2M HILL, 1993)
Trenching observations digitized from 1989 hand markup.
Prioritizing of source areas conducted 2012.
Prior remediation excavation areas from 1992 through 1994 digitized from Ecology and Environment, Inc., 1995.

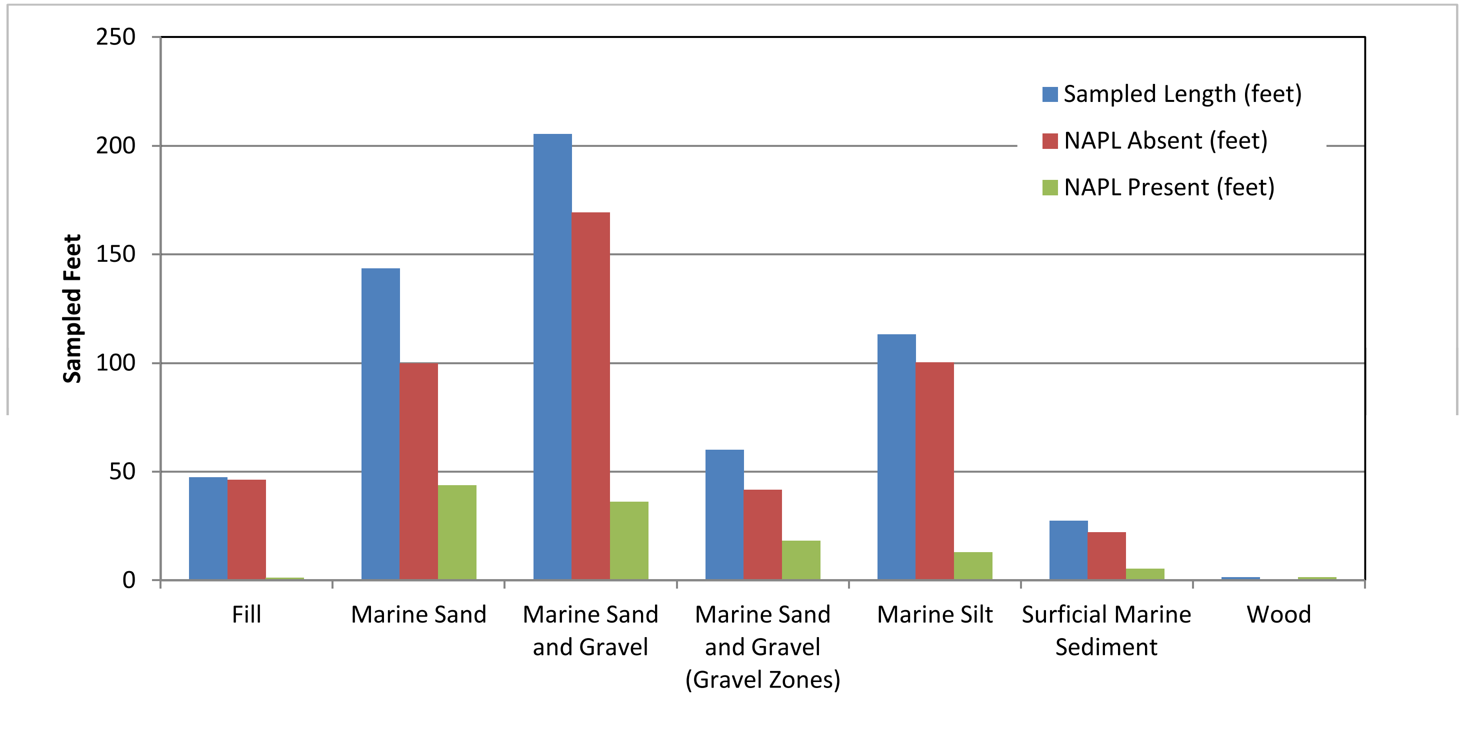
N

0 60 120 240 Feet

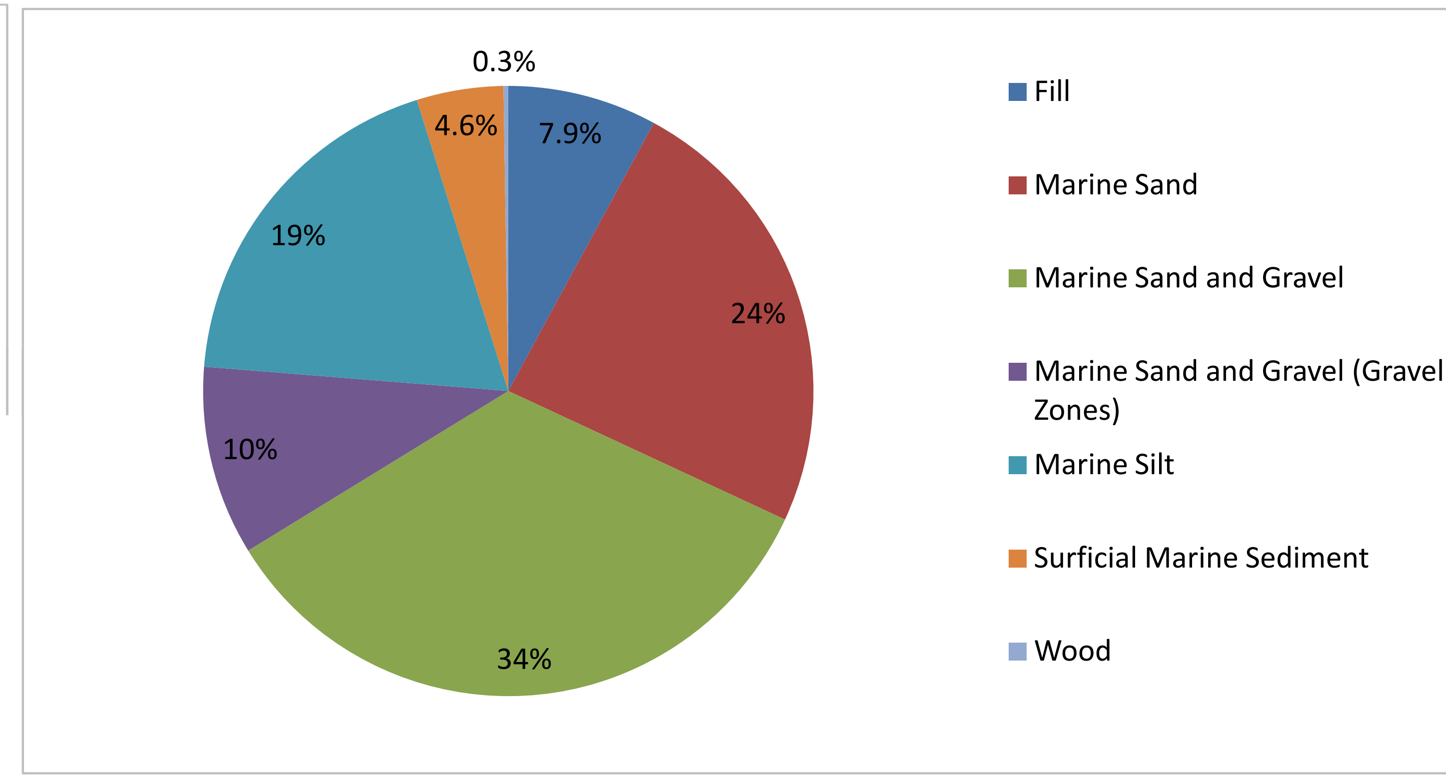
Figure 4-26
Confirmation Boring Locations
TarGOST Field Investigation

Wyckoff Upland Field Investigation
Wyckoff/Eagle Harbor Superfund Site

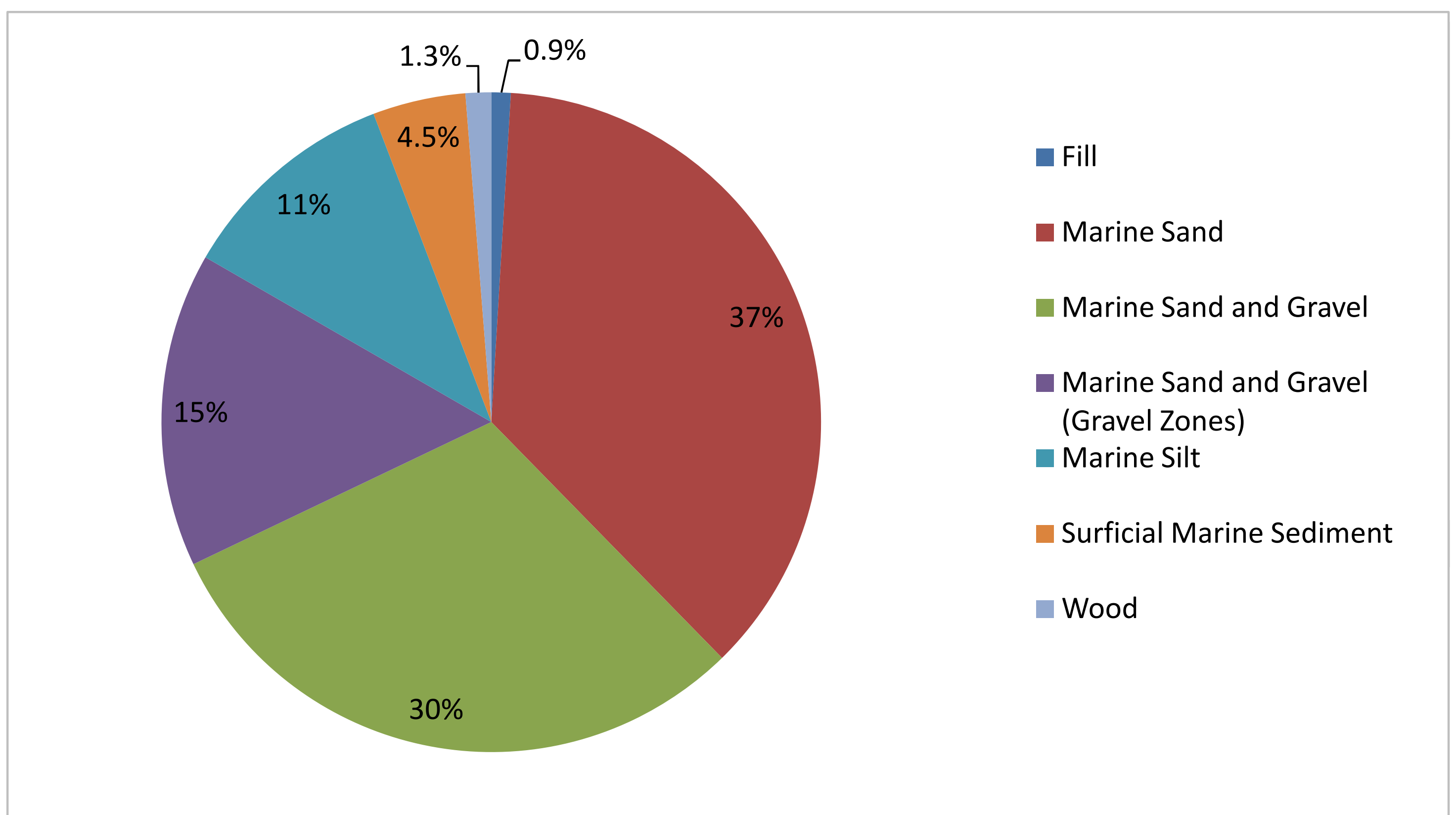
C:\USERS\GGEE\DOCUMENTS\GIS\WYCKOFF\MAPFILES\2013\FIELD INVESTIGATION SUMMARY MEMO\FIGURE4-20_CONFIRMATIONBORINGS.MXD GGEE 6/5/2013 2:20:15 PM



Summary of Lithology and NAPL Absence/Presence by feet



Summary of Lithology by Percentage of Confirmation Boring Footage



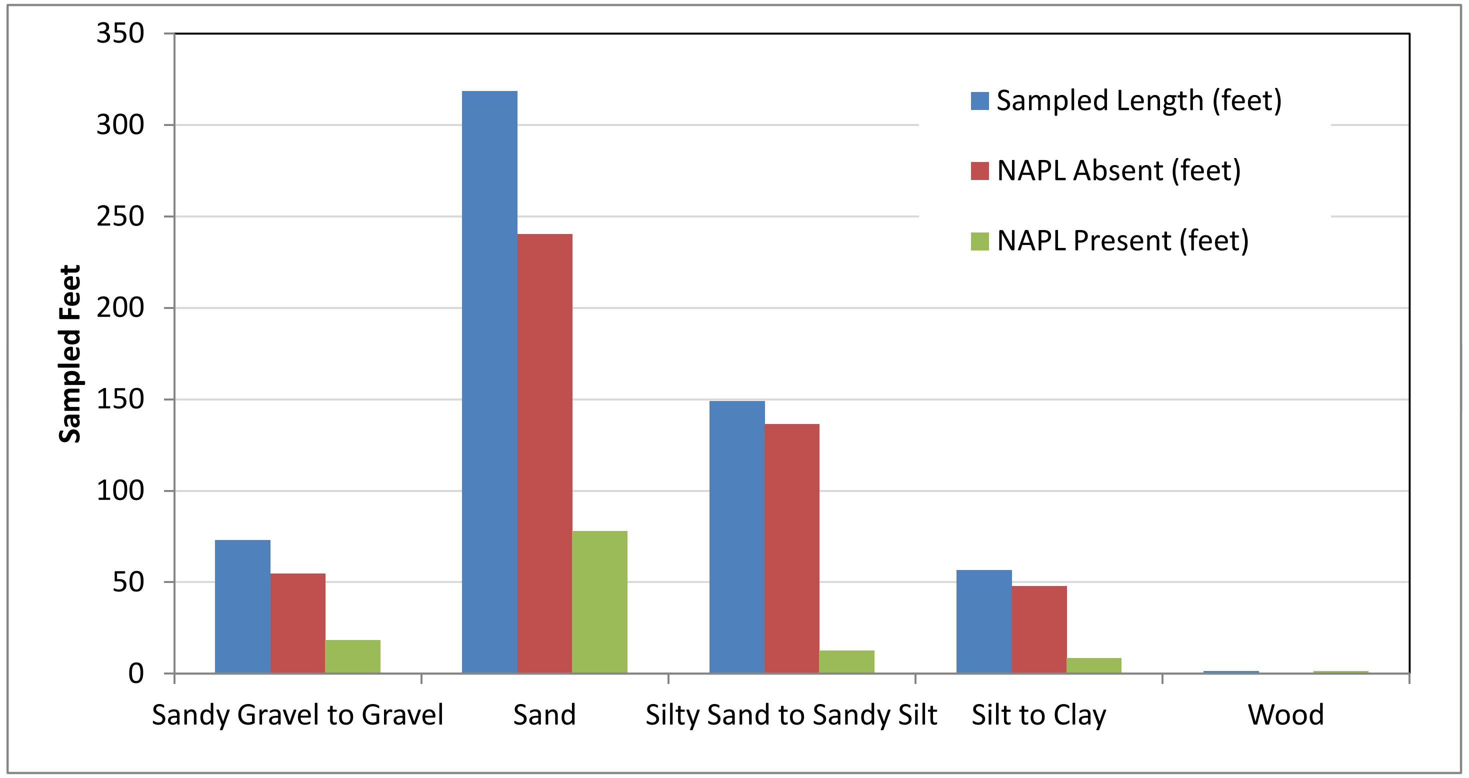
Summary of NAPL Presence in Lithology by Total Observed NAPL

Data Table

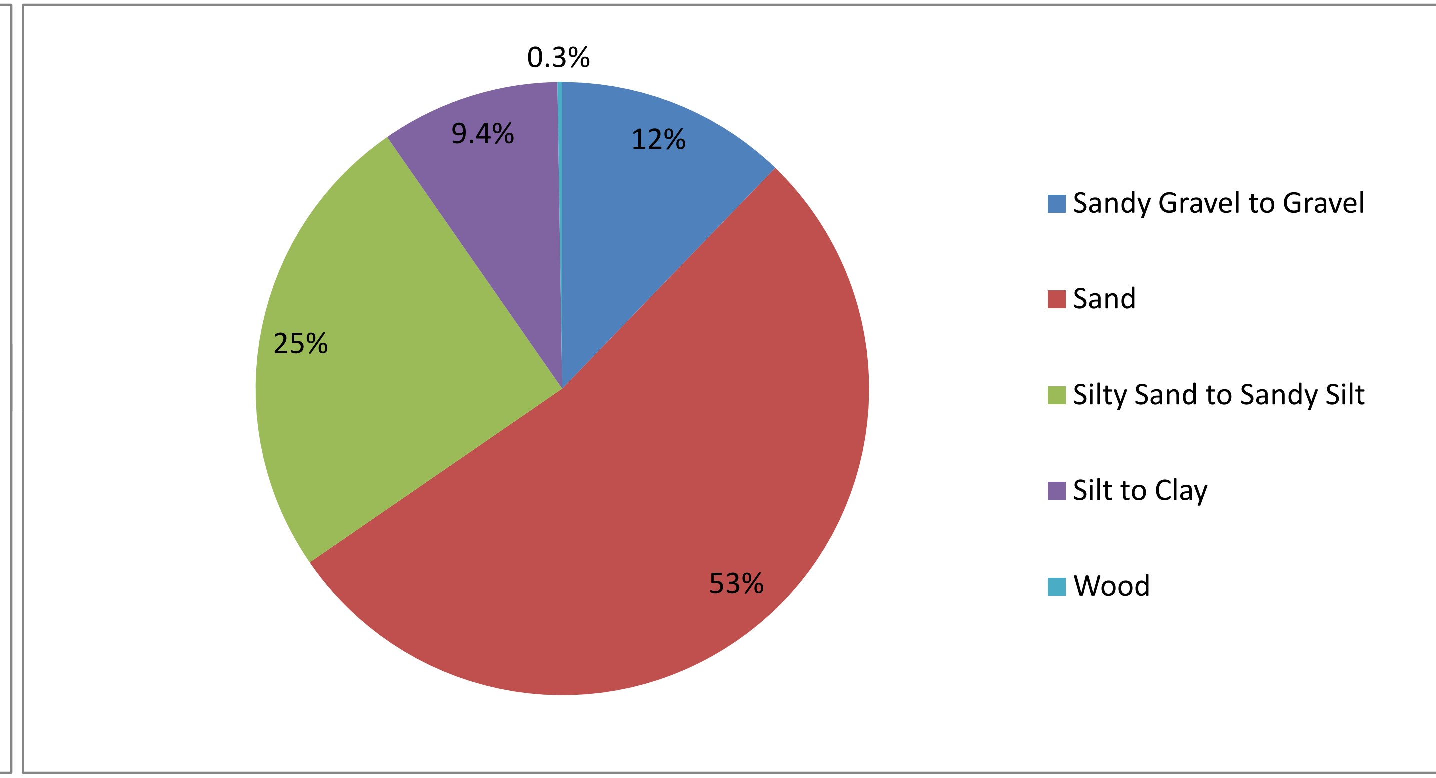
Lithology	Sampled Length (feet)	NAPL Absent (feet)	NAPL Present (feet)
Fill	47	46	1.1
Marine Sand	144	100	44
Marine Sand and Gravel	205	169	36
Marine Sand and Gravel (Gravel Zones)	60	42	18
Marine Silt	113	100	13
Surficial Marine Sediment	27	22	5.4
Wood	1.5	0	1.5
Grand Total	**598**	**479**	**119**

Figure 4-27
Confirmation Boring Lithology and NAPL Observations by Historical Geologic Unit Descriptions

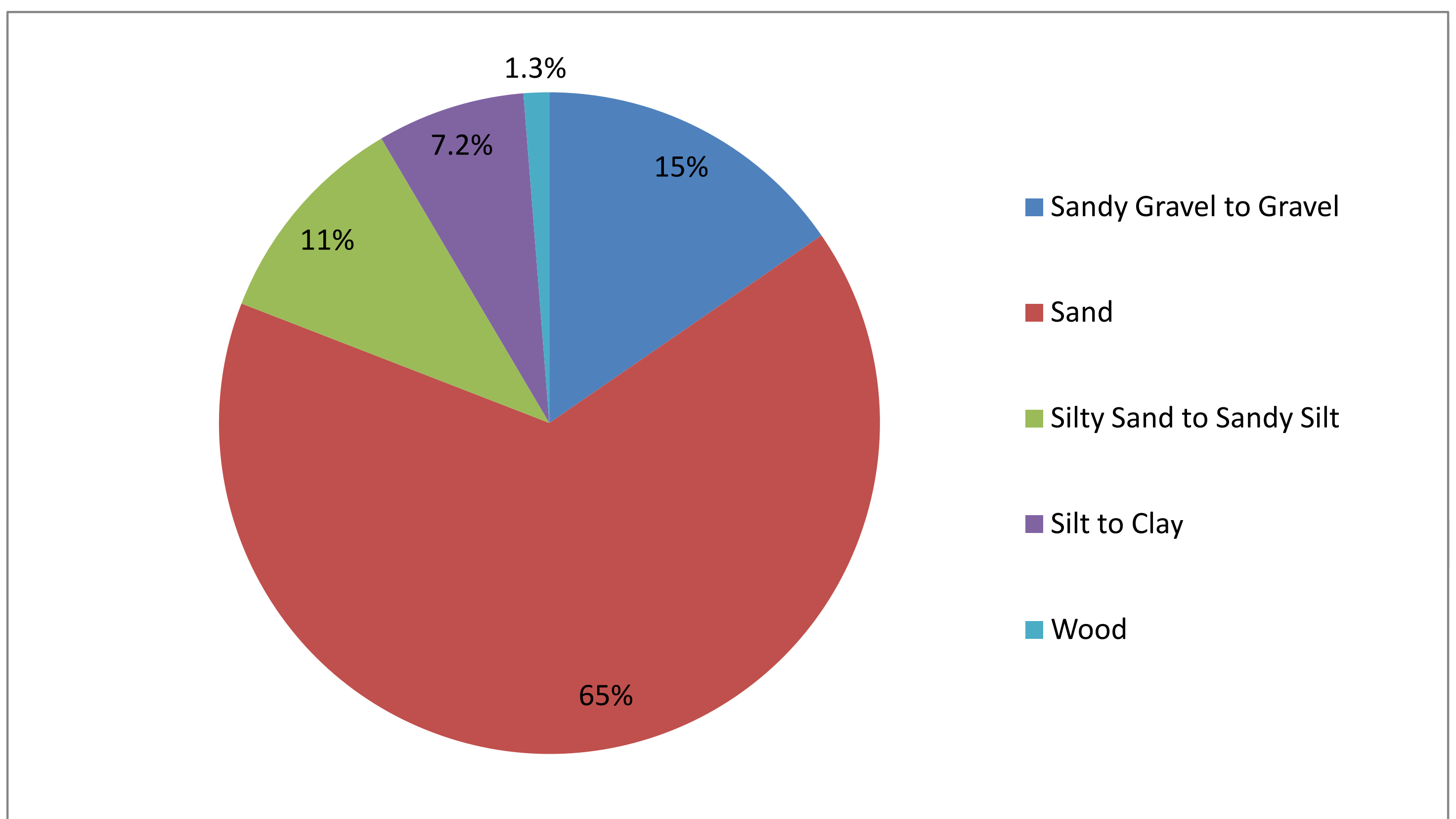
Wyckoff Upland Field Investigation
Wyckoff/Eagle Harbor Superfund Site



Summary of Lithology and NAPL Absence/Presence by feet



Summary of Lithology by Percentage of Confirmation Boring Footage



Summary of NAPL Presence in Lithology by Total Observed NAPL

Data Table

Lithology	Sampled Length (feet)	NAPL Absent (feet)	NAPL Present (feet)
Sandy Gravel to Gravel	73	55	18
Sand	318	240	78
Silty Sand to Sandy Silt	149	136	13
Silt to Clay	56	48	8.6
Wood	1.5	0.0	1.5
Grand Total	**598**	**479**	**119**

Figure 4-28
Confirmation Boring Lithology and NAPL Observations
by Selected USCS Soil Classes
Wyckoff Upland Field Investigation
Wyckoff/Eagle Harbor Superfund Site